REPORT

OF

A STUDY OF THE CALIFORNIA HIGHWAY SYSTEM

BY

THE UNITED STATES BUREAU OF PUBLIC ROADS

TO

THE CALIFORNIA HIGHWAY COMMISSION AND HIGHWAY ENGINEER

NEWELL D. DARLINGTON, *Chairman*
CHARLES WHITMORE
GEORGE C. MANSFIELD
AUSTIN B. FLETCHER, *Highway Engineer*

[ISSUED 1920 : REVISED 1921]

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

REPORT

OF

A STUDY OF THE CALIFORNIA HIGHWAY SYSTEM

BY

THE UNITED STATES BUREAU OF PUBLIC ROADS

TO

THE CALIFORNIA HIGHWAY COMMISSION AND HIGHWAY ENGINEER

NEWELL D. DARLINGTON, *Chairman*
CHARLES WHITMORE
GEORGE C. MANSFIELD
AUSTIN B. FLETCHER, *Highway Engineer*

[ISSUED 1920 : REVISED 1921]

WASHINGTON
GOVERNMENT PRINTING OFFICE
1922

RELIEF MAP OF CALIFORNIA, SHOWING STATE HIGHWAY SYSTEM.

(From the model by Prof. N. F. Drake of Leland Stanford University.)

CONTENTS

LIST OF PLATES

LIST OF TABLES

DEPARTMENT OF AGRICULTURE,
Washington, D. C., February 18, 1921.

The CALIFORNIA HIGHWAY COMMISSION AND HIGHWAY ENGINEER,
Sacramento, Calif.

GENTLEMEN: I take pleasure in transmitting a report of the study of the California highway system, made by the Bureau of Public Roads in compliance with your request of June 25, 1920. I trust this study may prove of service to the California Highway Commission and the people of California in continuing their program of highway development upon which such splendid advancement has already been made.

Very truly, yours,

E. T. MEREDITH, *Secretary.*

FOREWORD

AN adequate review of the results which have been secured by the development of any system of State highways must follow to-day an uncharted course. The essentials and nonessentials of such a task have not yet been sufficiently classified to avoid the gathering, on one hand, of material which modifies only slightly the final conclusions, or, on the other, to insure that all vital data and information is secured.

The California study is the most comprehensive study of results obtained through the development of a State highway system that has yet been undertaken. The work of this study has followed two principal lines, one that includes those questions that are engineering in character and the other those that are economic in character. These two groups of questions are so interrelated and so interdependent that they can not be separated. All road improvement is a means to an end—improved transportation facilities. The proper development of such facilities ought to be based on both the engineering and economic considerations involved. But the practical application of these considerations is always modified by the attitude of the public.

For the purpose of this study, the principal operation was to classify all the pavement laid. This classification covered 1,262 miles, from which a complete record of condition of all concrete pavement for each one-tenth mile resulted, and is supported by 7,500 consecutive photographs filed in the bureau. It is recorded completely by diagram. Associated with this classification there were drilled 638 cores through the pavement at intervals on 800 miles of the highway between Red Bluff and San Diego; 481 of these cores were tested and all were carefully examined and measured. A large number have been photographed for this report.

Twelve special, intensive studies of failed portions of the road surface resulted in a great volume of data which can only be summarized in the report, but which clearly establish in practically every instance the nature and cause of the defective pavement.

In connection with the many selected special studies, soil moisture determinations were made for cross sections of the road by borings at close intervals. Tests for moisture content, moisture equivalent, and for shrinkage were made at the laboratory of the University of California.

A complete classification of the subgrade soil under all the pavement on the State highway system was made by soil experts and plotted on the pavement condition diagrams. Below each concrete core samples of soil were also removed and classified.

A State-wide traffic census was taken at 103 stations for an equivalent 16-hour week day, and many Sunday and supplementary counts were also taken. This traffic record revealed the amount and character of travel for the summer interval on the State highways. It has resulted in a set of traffic diagrams from which the total annual duty of the California highway system has been estimated, and also the corresponding revenue, or the operating income to the community.

Supporting the traffic count, extensive field studies were made of the producing agricultural areas for 9 groups of agricultural crops and the peak load in tons and the peak interval in time for these crops was determined. This study covered the main valleys of the State.

During the progress of field investigation there was carried on at Sacramento a complete audit and analysis of all the books of the State highway commission office. This work resulted in a satisfactory and complete distribution of all costs of survey, construction, engineering and maintenance, and produced summaries that account for practically every dollar made available for the use of the commission.

Painstaking efforts have been made to secure all the data necessary to present the conclusions impartially and uncolored. There is much of value in the record to be made available after more research.

Within the past five years an unprecedented demand has been made upon the highway administrator and highway engineer to produce a large mileage of economical and serviceable highways. The extent to which he has produced this combined result is the true standard of measurement of his achievement.

Let the present traffic service rendered by the State highways of California, conservatively estimated, we believe at 400,000,000 vehicle-miles per year, be multiplied by any reasonable unit rate to indicate the present annual returns to the people on the total investment to date of about $42,000,000.

Now turn to one paragraph from the report selected as the most vital to be repeated here:

> The financial administration has been scrupulously honest and careful and the administrative and engineering costs have not been excessive, nor have final costs much exceeded the engineer's estimate.

There should be no hesitation in going forward with confidence.

The bureau gratefully acknowledges the cooperation and assistance extended by the Bureau of Soils of the Department of Agriculture, the Bureau of Standards of the Department of Commerce, the University of California, the California Highway Commission, and the highway engineer.

The field studies and the preparation of this report were carried forward under the immediate direction of Dr. L. I. Hewes and T. Warren Allen, general inspectors of the Bureau of Public Roads.

THOS H. MACDONALD,
Chief of Bureau.

FEBRUARY 18, 1921.

DECEMBER 21, 1920.

Mr. T. H. MACDONALD,
Chief of the Bureau of Public Roads,
Washington, D. C.

In accordance with your telegraphic instructions of July 8, following the request of June 25, 1920, from the California Highway Commission and highway engineer, a study has been made to determine the operations under the three California State highway bond issues and the costs thereof, the present condition of the roads built and so far as possible the causes of existing conditions and also to determine a measure of the usefulness and duty of the highway system, and to develop recommendations for the future. A report of this study is hereby submitted in three parts which refer, respectively, to data, discussion, and conclusions.

Acknowledgment of the continuously courteous response by the State highway commission and the highway engineer to every request to facilitate this study is gratefully recorded.

Very respectfully,

L. I. HEWES, *General Inspector.*

DATA

HISTORICAL

CALIFORNIA, in common with other States, experienced the preliminary processes associated with the adjustment of highway conditions to the demands of developing industry. Some of the earliest road work was done by private individuals or corporations and the roads operated as toll roads. These roads were later taken over by the State.

A definite movement by the State for improved highways began March 27, 1895, by a legislative act providing for a bureau of highways of three members to be appointed by the governor for terms of two years. The duties of this bureau included a study of the highway laws of California and of other States, a study of the physical features of the State and their relation to a system of roads, and of the economic and legal status of the highways in each county in the State, together with a study of the road work done in the preceding ten years by the counties, and costs therefor, and a report with conclusions and recommendations of such measures as the bureau deemed advisable.

The bureau of highways was organized April 11, 1895, and November 25, 1896, rendered a report recommending a proposed system of State highways of 28 routes. The report stated that the principles had in mind in outlining a system of highways were:

First. To lay them out along the lines which the physical features of the State forever fix as the easiest lines of communication.

Second. To traverse the great belts of natural wealth of the State by one or more highways.

Third. To connect all the large centers of population.

Fourth. To reach each county seat in the State and tie in with the county roads.

The report with a map showing the State road system recommended is filed in the documents department of the State library in Sacramento. A copy of the map, designated "System recommended in 1896," is attached to this report as Plate I.

The report shows that the total amount expended by counties on highway work during the period of 1885–1895 approximated $18,000,000, and states "no adequate return therefor is apparent." In Appendix A of the original report of the bureau of highways are shown the road expenditures by counties for the years 1886 to 1895, inclusive.

The members of the bureau of highways, in addition to their other duties, traveled about the State to acquaint themselves with highway conditions and requirements, and it is probable that the State-wide inspection and study made by them, as reflected in their report and bulletins, was later a valuable guide to the State highway commission in its work of laying out the system which is now building. This is evidenced by the closeness with which the present system coincides with that shown on the 1896 map. No funds for construction were provided by the act of 1895.

This act of 1895 was repealed in April, 1897, and a department of highways was created. The department of highways act provided for three highway commissioners to be appointed by the governor, to serve for a period of two years, at the end of which time the governor was to appoint for a term of four years and every four years thereafter one civil engineer as highway commissioner, in whom should be vested all the powers and duties attaching to commissioners first appointed under this act. These appointments were made as required by law and the department of highways carried on certain work until 1907, when it was merged by legislative enactment into the State department of engineering. The money appropriated from time to time by the State legislature for certain "State roads" was expended under the direction of this department of highways. The details of work done and money expended are shown in the published reports, copies of which are on file in the document department of the State library at Sacramento.

In 1907 the State department of engineering was created by law. It was composed of an advisory board consisting of the governor as ex officio member and chairman, the State engineer, general superintendent of State hospitals, and the chairman of the State board of harbor commissioners of San Francisco. The State engineer was appointed by the governor.

The legislature of 1907 took action to forward road building in the State, by what was known as the Savage Act, which permitted counties to bond their whole property for road improvement purposes.

After the creation of the original bureau of highways the California Legislature from time to time took over certain wagon roads as "State roads." These special roads have been almost exclusively roads in the mountainous regions and only nominal appropriations were made for their improvement. The total of such appropriations up to 1913 for all these roads was $807,243. These roads were later in charge of the State department of engineering and doubtless pre-

pared the public and the legislature for the more important legislation of 1909.

With the support of the governor agitation for an improved highway system in 1909 became acute and resulted in the passage by the legislature of the "State highways act" of March 22, providing for an issue of bonds to the amount of $18,000,000 for the construction and acquisition of a system of State highways.[1] This act was approved by a majority of the electors of the State November 8, 1910.

The legislature of 1911 passed what is commonly known as the "Chandler Act," adding three members to the department of engineering, to be appointed by the governor, whose duty would be to carry out the provisions of the first highway bond issue. At a meeting in August, 1911, of the advisory board of the department of engineering, an enabling resolution designated the three members appointed under the "Chandler Act" as an executive committee to be known as the California Highway Commission, and vested in the commission the actual handling of the work of constructing and acquiring the State highway system under the bond issue of 1909. A highway engineer was appointed by the governor and was made executive officer of the commission.

A law passed in March, 1905, provided for registration of motor vehicles with a fee of $2.00. There were minor amendments in 1907, and in 1913 an act known as the motor vehicles act was passed requiring annual registration of motor vehicles and increasing the fee for such registration. This act was amended by an act of 1915, and again in 1917 and 1919. The act of 1913 provided that half the net proceeds of motor vehicle licenses should be returned to the respective county road funds, and that the remainder should be devoted to the maintenance of State roads and highways, and the amendment of 1915 changed the wording to permit such moneys to be used also for improvements of State roads and highways. Further details of the motor vehicle laws will be found in Appendix C.

The advisory board imposed upon the California Highway Commission the further duty of maintaining the State highways constructed under the "State highways act." In 1915 the State legislature passed the second "State highways act" providing for a second issue of bonds for $15,000,000. This act was indorsed by the people at an election in 1916.

The State legislature of 1917 gave the California Highway Commission statutory recognition as a subdivision of the department of engineering, expressly prescribed its powers and duties, and transferred all State roads theretofore constructed under the supervision of the State engineer to the commission.

The California Highway Commission thus in 1917 became a statutory body in immediate control and supervision of all State road and State highway activities of California, and is now carrying out the provisions of the bond issues of 1909 and of those of 1915 and 1919. The bond issue of 1919 for $40,000,000 was submitted by the legislature to the vote of the people July 1, 1919, and carried. In the campaign for this bond issue the California State Automobile Association of San Francisco and the Automobile Club of Southern California of Los Angeles were active advocates of the law.

The California State highway bonds are all of the deferred serial type and with maximum terms of from 40 to 45 years. The beginning of the repayment of principal is deferred about seven years in each issue. The counties were required by the original State highways act to pay the entire interest on those bonds, the proceeds of which are expended by the State Highway Commission within their respective boundaries.

The bond issue of 1909 for $18,000,000 was carried by a bare majority. The second serial bond issue, that of 1916 for $15,000,000, was carried by every county in the State by a vote of nearly four to one. The third serial bond issue, that of 1919 for $40,000,000, carried by a vote of approximately seven to one. Further details of each bond issue are described in Appendix A.

There is shown graphically in Plate II the progress of the total tax requirements to pay interest and principal for the first two bond issues which total $33,000,000, and in the same figure the approximate progress of necessary total payments of both interest and principal on all the issues which total $73,000,000.

The State highways act of 1909, which provided the first bond issue, stated:

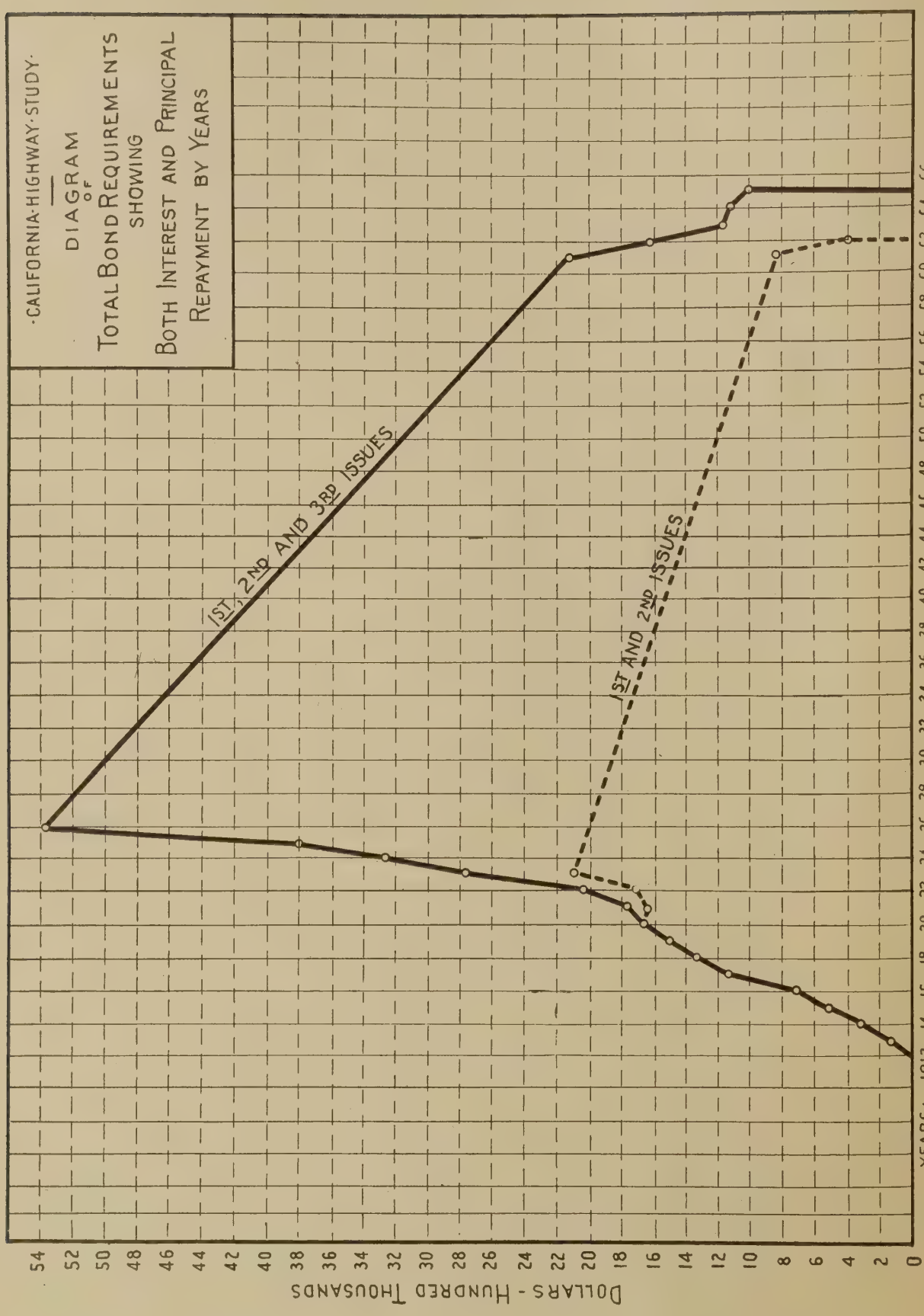
> The moneys placed in the State highway fund, pursuant to the provisions of this section, shall be used exclusively for the acquisition of rights of way for and the acquisition and construction of said system of State highways. The route or routes of said State highways shall be selected by the department of engineering and said route shall be so selected and said highways so laid out and constructed or acquired as to constitute a continuous and connected State highway system running north and south through the State traversing the Sacramento and San Joaquin Valleys and along the Pacific coast by the most direct and practicable routes, connecting the county seats of the several counties through which it passes and joining the centers of population, together with such branch roads as may be necessary to connect therewith the several county seats lying east and west of such State highway. * * * The highway constructed or acquired under the provisions of this act shall be permanent in character and finished with oil or macadam, or a combination of both, or of such other material as in the judgment of the said department of engineering shall be most suitable and best adapted to the particular locality traversed.

[1] For details of the three State highway bond issues see Appendix A.

PLATE I.


BUREAU OF PUBLIC ROADS
U S DEPT OF AGRICULTURE
OUTLINE MAP
OF
CALIFORNIA
OUTLINING THE STATE HIGHWAY SYSTEM
RECOMMENDED BY
THE BUREAU OF HIGHWAYS
NOVEMBER 16
1896
OREGON
NEVADA
ARIZONA
MEXICO

PLATE II


·CALIFORNIA·HIGHWAY·STUDY·
DIAGRAM
OF
TOTAL BOND REQUIREMENTS
SHOWING
BOTH INTEREST AND PRINCIPAL
REPAYMENT BY YEARS
1ST, 2ND AND 3RD ISSUES
1ST AND 2ND ISSUES
DOLLARS - HUNDRED THOUSANDS
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54
YEARS: 1912 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66

The routes selected by the commission in compliance with this law totaled 3,082 miles and are shown in detail in Appendix A and in the frontispiece and Plate III.

The second bond issue provided by the legislative act of May 20, 1915, was emphatically approved by the voters in November, 1916. The State highway commission by the end of that year had constructed approximately 835 miles of concrete pavement and graded 323 miles in addition, and it was obvious that the original $18,000,000 was insufficient to complete the original system. The funds from the new bond issue were not available until July, 1917, but the old fund was exhausted January, 1917. To carry on work during the intervening months money was borrowed from the motor-vehicle fund.

The State highways act in 1915 stated:

> Of the moneys placed in the said second State highway fund, pursuant to the provisions of this section, the sum of $12,000,000, or so much thereof as may be necessary, is hereby made available, and shall be used exclusively for the acquisition, construction, and improvement of the uncompleted portions of the system of State highways prescribed by said "State highway act" (act of 1909). And of said moneys so placed in said second State highway fund, the sum of $3,000,000, or so much thereof as may be necessary, is hereby made available, and shall be used exclusively for the acquisition, construction, and improvement of certain extensions from said system of State highways prescribed by said State highways act[2] * * *: *Provided, however*, That expenses of the acquisition, construction, and improvement of the extensions above enumerated and the acquisition of right of way therefor shall be partly borne by the county or counties in which said extensions lie, the extent and character of such division of expenses between the State and county shall rest for final determination with the State department of engineering, and the State department is hereby authorized to enter into such agreements and undertakings as are necessary to properly carry out the intent of this section.

The first biennial report of the California Highway Commission was issued December 31, 1918,[3] and closes with the remark:

> The data embodied herein may suggest still further legislation, and any cooperation by the legislature of 1919 tending to the betterment of State highway work will be appreciated by the commission.

The legislature of 1919 passed the third bonding act and on July 1, 1919, at a special election called for the purpose the electors indorsed the act.

This State highway act of 1919 states:

> The moneys in said "third State highway fund" shall be used by the State department of engineering for the acquisition, construction, and improvement of uncompleted portions of the system of State highways prescribed by the act of the legislature approved May 22, 1909, known as the "State highways act," and the act of the legislature approved May 20, 1915, and known as the "State highways act of 1915," and certain extensions thereof described in said last-named act, and also for the acquisition of the rights of way for and the acquisition, construction, and improvement of the following additional highways as State highways.[4]

With these extensions the designated State highway system now totals 5,560 miles.

It is to be noted that the California State Automobile Association and the Automobile Club of Southern California both took an active part in campaigning in favor of the various bond issues and more recently in the campaign to authorize an increased interest rate for the third bond issue.

Except for separate appropriations for salaries and expenses of commissioners and highway engineer, the funds put at the disposal of the State Highway Commission consist of those funds derived from the sales of bonds issued, 50 per centum of the net money collected on account of the State motor vehicle act, certain county, municipal, and private funds, special State appropriations, and Federal-aid funds. The total of these funds up to July 1, 1920, is $42,007,330.07, made up as follows:

First bond issue	$18,002,129.00
Second bond issue	13,000,025.00
Third bond issue	3,000,000.00
Motor-vehicle funds	6,539,563.21
County, municipal, and private funds	632,120.73
Special State appropriation	265,308.36
Federal-aid funds	568,183.77
Total	42,007,330.07

The total expenditure for construction and maintenance to July 1, 1920, is $41,790,884.41.

[2] There follows in the law a list of 698 miles of prescribed extensions given in detail in Appendix A and which are shown in the maps of the frontispiece and Plate III.

[3] First biennial report of the California State Highway Commission, a subdivision of the department of engineering of the State of California. Dec. 31, 1918. 142 pp. A complete report of activities of the commission to July 1, 1918.

[4] There follows in the law a description of 30 adjoined routes which total 1,798 miles and which are shown in the maps of the frontispiece and Plate III, and listed in Appendix A.

SYSTEMS DESIGNED

The system of State highways laid out in 1896 by the old bureau of highways totaled approximately 4,500 miles, which was about 10 per cent of the total of 45,056 miles. No construction was done on this system as such.

The law authorizing the bond issue of 1909 provided for a system of highways and the laws of 1915 and 1919 extended the 1909 system as above mentioned. Complying with the conditions imposed by law the State Highway Commission laid out the road system shown on the relief map[5] of the frontispiece, which also shows separately the adjoined routes provided by the acts of 1915 and 1919.

The mileage of the system of 1909 is approximately 3,082, or 6.4 per cent of the estimated total mileage of 45,069.[6] In 1916 the total mileage in California was estimated by the United States Bureau of Public Roads at 61,039. The combined mileage of 1909, 1915, and 1919 is 5,560, or 9.1 per cent of the total estimated road mileage in the State for 1916.

Plate III is a map showing the system laid out by the State Highway Commission in following out the provisions of the law of 1909, and separately the adjoined roads described in the highway acts of 1915 and 1919, and the relation of all these roads to the land classed as agricultural. The combined system is divided into numbered routes and these routes within each county are subdivided into lettered sections. The roads in this combined system are those which the State Highway Commission has been engaged in improving.

RELATION OF TOTAL SYSTEM TO AGRICULTURE AND POPULATION.

It will be seen from Plate III that, although the system of highways laid out by the commission under the act of 1909 is a restricted through system which in general parallels the railroads, it supplies, to a considerable extent, market roads for the great agricultural valleys. The land classed in this map as agricultural is plotted from the data of the United States Bureau of Soils and from that of the University of California. It is clear that the systems adjoined by the legislatures of 1910 and 1919 are also well placed to serve additional market areas.

The system of roads laid out in compliance with the act of 1909 served directly about 47 per cent of the State population exclusive of the people of San Francisco and Los Angeles (as listed by the detailed census figures of 1910 for incorporated cities). These proposed roads also served directly an additional unknown percentage of the rural population living in small unincorporated places and consequently not listed separately in the census but on the highway, and lastly an undetermined increment of rural population not living in such incorporated and unlisted cities but close to the highways. If the cities of San Francisco and Los Angeles are included it may, therefore, be estimated that at least 66 per cent of all the people in California in 1910 lived on or immediately adjacent to the highway system laid out under the first bond issue.

The available 1920 census figures show that at present 54 per cent of the population of California, exclusive of San Francisco and Los Angeles, live in places on or immediately adjacent to the system of highways now built or projected (including those highways to be built under the third bond issue). Furthermore, the figures show that while the total increase of population in the State was 44 per cent from 1910 to 1920, the increase in listed population only on the highway built and proposed and not including San Francisco and Los Angeles was 63 per cent.

ORGANIZATION

The organization of the State highway department as modified January 15, 1920, is shown in Plate IV. The principal change made at that time was an increase in the highway engineer's staff from one to six. This staff now consists of a construction engineer, a maintenance engineer, an equipment engineer, a bridge engineer, and two general inspectors. The construction engineer is the senior staff engineer and in the absence of the highway engineer acts in his stead. The general inspectors, one assigned to the northern part of the State and the other to the southern, act as the field representatives of the highway engineer.

It is believed that the recent increases in the staff will considerably facilitate the handling of the great volume of business passing through the offices of the highway engineer.

Other branches of the headquarters organization are a legal department, which handles right-of-way matters, a disbursing department, an accounting de-

[5] From the model by Prof. N. F. Drake, of Leland Stanford University.

[6] Estimate by the U. S. Bureau of Public Roads in 1909. A similar estimate for 1904 was 46,653.

PLATE III.


OUTLINE MAP
OF
CALIFORNIA
SHOWING
STATE HIGHWAY SYSTEMS FOR 1909-15-19
AND
AGRICULTURAL AREAS
TO ACCOMPANY REPORT OF
CALIFORNIA HIGHWAY STUDY
1920
LEGEND
6
23
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC
SAN FRANCISCO
SAN DIEGO
1
2
3
4
5
6
7

1920
·ORGANIZATION· CHART·
·CALIFORNIA·HIGHWAY· COMMISSION·

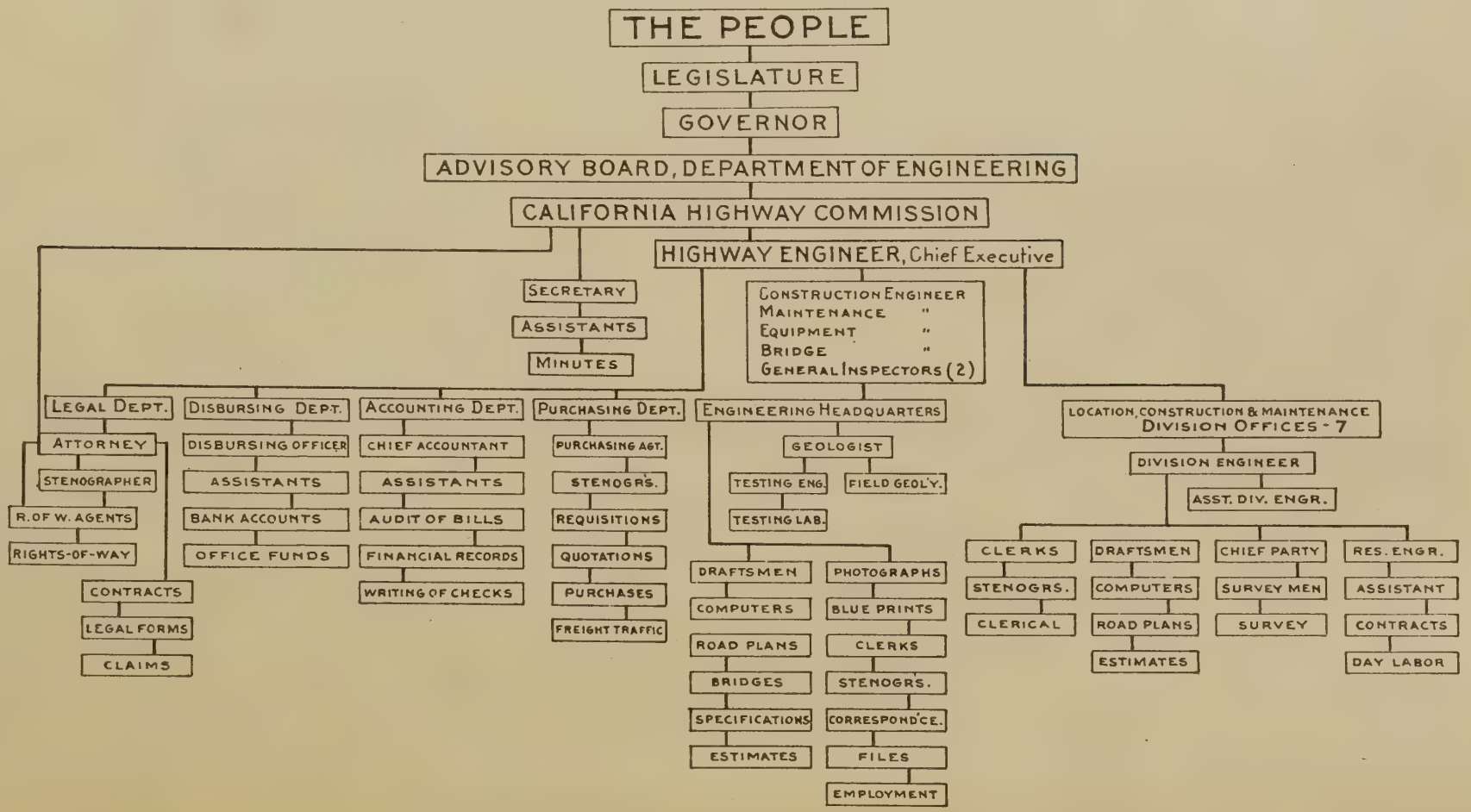


PLATE VI.

partment, a purchasing department, and a headquarters engineering department, all of which are shown on the chart, with a suggestion of their duties.

The headquarters organization at Sacramento at the present time consists of about 71 employees.

The State is subdivided into seven divisions, with a division engineer in charge of each. A division office is maintained in the principal city in the division. The division engineer has responsible charge of the location, construction, and maintenance of the State roads and highways in his division and reports to the highway engineer.

The number of assistant division engineers in each division depends on the size of the division and the volume of the work under way. Usually there are two in the larger divisions, one the division construction engineer and the other the division maintenance engineer. In the absence of the division engineer the division construction engineer acts in his stead. There is also an office engineer who reports directly to the division engineer.

In each division there are the necessary chiefs of survey party on location, chiefs of survey party on construction, resident engineers, assistants, etc.[7]

The procedure in the case of a project proposed by the commission for improvement is approximately as follows: First the division engineer is directed to make a reconnaissance. If the reconnaissance is favorably received, the commission directs the highway engineer to proceed with surveys, plans, and estimates. The appropriate divison engineer is then notified of this action, and this is his authority to proceed.

The division engineer designates the controlling points of the survey and assigns a chief of party to the work. No definite estimates of cost of surveys and plans are made in advance. The surveys follow detailed instructions issued by the highway engineer. The so-called "base-line method" has been uniformly used. Drafting and designing is done, as a rule, at the division office and not in the field. The division engineer forwards completed plans to Sacramento, whereupon field inspections are made and plans are examined and checked in a general way. The necessary bridge and structural designs are made in the bridge department.

The law requires that work be advertised in papers of local and general circulation for four weeks. If excessive bids are received, the commission may order the work readvertised or done by day labor.

The preliminary estimate, as approved by the highway engineer, becomes the estimate used in the consideration of bids. Upon receipt of bids and award of contract, allotment equal to the total price bid, plus the cost of materials furnished by the State, plus 3 per cent for contingencies, is made for the project. The engineering expense of handling the project during construction is covered by a separate allotment.

Upon award of contract and allotment of funds the division engineer is authorized to proceed with the construction engineering work. He assigns a construction survey party to this work. This party stakes out the line in accordance with the approved design and general instructions, after which a resident engineer with the necessary assistants is assigned to the work. The resident engineer's duty is to see that the job is completed in accordance with the contract and specifications, and further to furnish the information upon which the division engineer bases partial payment estimates. The information for the partial-payment estimate is to be prepared so as to reach the division engineer's office by the Saturday nearest the 15th of the month.

Estimates are prepared and checked in the division office, signed by the resident engineer and division engineer, forwarded to the office of the highway engineer, where they are again checked and then sent to the comptroller. The comptroller, if satisfied that payment should be made, places the amount of money called for in the estimate at the disposal of the State highway engineer, after which the disbursing office issues a check to the contractor. The average time from estimate to payment is about 14 days.

The resident engineer assists the division engineer in preparing the final report and the final estimate. This estimate is signed by the resident engineer and the division engineer, and transmitted to the highway engineer with the final report on the work. The estimate is there checked and payment made as in the case of partial-payment estimates. The average time from estimate to payment for the final estimate is about 35 days.

Maintenance work in the larger divisions is handled by a division maintenance engineer, in the smaller divisions directly by the division engineer. Maintenance is divided into general maintenance, which consists in maintaining the road in the condition in which it is left upon completion of construction and in improvement, which consists in relocation or new work and in reconstruction. Reconstruction consists in the rebuilding of considerable portions of the work. The division engineer makes a detailed estimate quarterly of the amount needed for the general maintenance of each of the State highways in his division. This amount, when allowed, becomes an allotment for the work. In the case of improvement or reconstruction an estimate

[7] The State civil service commission through examination, open to any American citizen resident in California, supplies to the Highway Commission employees below the grade of State highway engineer. There are six classified grades in the highway engineer group. Grade I includes junior draftsmen, rodmen, and chainmen, at salaries of $100 per month, or $85 per month and board, respectively; and Grade VI includes the assistant highway engineers and division engineers, at salaries of $325 to $400 per month. Competitive examinations are required for promotion from one grade to another, and the civil service must sanction promotion within grades.

75712—22——2

is made by the division engineer at such times as he deems such work necessary, and this estimate is handled in the same way as an allotment for a new project. A record of the cost of maintenance, subdivided as described above, is kept in the highway engineer's office.

Beginning in April, 1920, all the division engineers and assistant highway engineers have been required to meet at the headquarters office in San Francisco on the first Monday of each month.

CONVICT LABOR.

The legislature passed a law April 27, 1915, permitting the department of engineering to employ State convicts on State highways under its supervision, but placing the discipline and control of convicts under jurisdiction of the prison directors. The entire expense of convict work is borne by the department of engineering. The convicts must not do any work of "skilled labor." Their terms may be shortened not to exceed one day for two on the road.

Under this law up to November 1, 1920, grading of about 115 miles of road in the remote districts of northern California in Divisions I and II has been completed. At present about 220 convicts are at work. The maximum number of convicts reported employed at one time in one camp was 225 in July, 1917, in Mendocino County. The total number of convicts shipped to the two camps in Mendocino and Humboldt Counties since September, 1915, is 955; of these 33 escaped and were recaptured and 16 others who escaped were not recaptured.

The following tabulation shows the distribution of costs per man-day:

CONVICT COSTS, DIVISION I, TO SEPTEMBER 30, 1920.

	Mendocino camps.	Humboldt camps.
Guards	$0.132	$0.237
Transportation	.170	.180
Clothing	.250	.182
Subsistence	.952	1.013
Housing	.165	.198
Escapes	.035	.040
Medical	.055	.069
Tobacco	.052	.071
Cost per man day	1.811	1.990
Cost per effective man-day	2.830	3.05

CONVICT COSTS, DIVISION II.

Food	$0.78
Hauling	.023
Transportation	.043
Guarding	.148
Clothing, medical, tobacco	.152
Escapes	.084
Depreciation equipment	.035
Camp maintenance	.015
Preparing and issuing food	.052
Cost per man-day	1.332
Cost per effective man-day	1.97

The term "effective man-day" means days actually worked and excludes Sundays, bad weather, sickness, etc.

Excavation, including clearing and grubbing and averaging 65 per cent solid rock totaled in Division I, to September 30, 1920, in Mendocino County, 939,100 cubic yards at $0.838, and in Humboldt County 36,000 cubic yards at $1.333. In Division II, 500,000 cubic yards "mostly solid rock" cost $0.70.

The average cost per mile of 57.5 miles of road in Mendocino and Humboldt Counties is approximately $15,000 for heavy mountain road, 18 to 21 feet wide for 35.0 miles and 12 to 16 feet wide for 22.5 miles. In Nevada and Sierra Counties 41 miles of about 14-foot mountain road cost $12,195 per mile.

SPECIFICATIONS.

The principal features of the specifications in use since 1912 are described below:

Embankments and subgrade.—The specification provides that the engineer may require puddling of fills greater than 12 inches. The 1913 to 1918 specifications require that all finished fills and cuts shall be watered and rolled until the surface is smooth and unyielding. In the 1919 and 1920 specifications these provisions are incorporated in the specifications for subgrade.

Concrete pavement.—The commission adopted a standard specification for concrete pavement in 1912, which has not been extensively changed until the present year, except with respect to the proportions of the concrete, which in 1917 was made 1:2:4 instead of 1:2½:5, as originally adopted. All cement is required to conform to the requirements of the American Society for Testing Materials.

With reference to the fine aggregate, the specification permits 6 per cent by weight of clay, silt, and other material, passing a No. 100 standard sieve. There are brief specifications regarding the quality and grading of coarse aggregate.

In the present specifications there are no slump-test requirements for the concrete. The original specifications provided for mixing until the mixture was of uniform texture and color. In 1916 the requirement was 10 turns of the mixer and a minimum interval of one minute.

With reference to surface finish, the 1912 specifications provided for hand tamping and roughening by raking. The 1913 to 1915 specifications provided that the pavement should be finished by hand tamping until the mortar flushed freely to the surface and the 1915 to 1916 specifications, in addition, prescribed that the finished surface should not vary more than one-quarter inch when tested by a straight-edge 5 feet long. There was no requirement until 1919 for striking off or floating or troweling. In 1919 the specifications required the surface to be finished by rolling and belting.

It is believed that the California commission first extensively used the method of ponding in curing concrete pavement. In 1913 the time of wetting was in-

creased from 6 to 10 days. The 1919 specifications specifically provided for curing by ponding or covering with wet earth. There were no specifications for expansion joints, except on one contract in 1916 in Marin County.

No reinforcing was required by the specifications except in 1920, beginning with contract No. 271. General instructions to division engineers No. 421, issued May 1, 1920, orders reinforcement of concrete bases and shoulders by one-half-inch square deformed steel bars placed in the center plane 2 inches from the outside edge lapped 12 inches and butted at 30-foot intervals; transverse reinforcement, three-eighths-inch square deformed steel bars 18-inch centers hooked over the longitudinal bars and wired thereto; all steel is to be temporarily supported by short lengths of iron pipe. General instructions to division engineers No. 427, issued September 15, 1920, read:

Voted that hereafter because of the rapidly increasing volume and intensity of the traffic over the State highways, no concrete base be laid on any State highway of lesser thickness than 5 inches and all concrete bases are to be reinforced with steel as heretofore ordered.

Although not explicitly called for in the printed specifications, reinforcement has from time to time been incorporated in the pavement and is of various types.

Topeka.—With reference to the specifications for Topeka pavement, there have been no changes since 1912. A consistency of bituminous material of from 70 to 90 as determined by penetration is permitted.

Oil macadam.—With reference to oil macadam, the specifications provide for water-bound macadam construction with surface treatment at the rate of seven-eighths to 1¾ gallons per square yard, the oil to be not less than 85 per cent asphalt with a penetration of 80.

Oil top.—An analysis of the three-eighths-inch oil-skin top is shown in Table 1.

TABLE 1.—*Analysis of bituminized aggregates used in oil top.*[1]

Location.			B. P. R. Lab. No.	Passed ½ inch, retained ¼ inch.	Passed ¼ inch, retained No. 10.	Passed No. 10, retained No. 20.	Passed No. 20, retained No. 30.	Passed No. 30, retained No. 40.	Passed No. 40, retained No. 50.	Passed No. 50, retained No. 80.	Passed No. 80, retained No. 100.	Passed No. 100, retained No. 200.	Passed No. 200.	Per cent of bitumen.	Total per cent.
Route.	County.	Section.													
12	San Diego	B	16814	1.6	18.0	11.6	8.8	6.0	7.2	8.4	3.6	8.0	14.9	11.9	100.0
2	Orange	A	16815	7.6	36.0	15.8	7.2	3.6	3.6	3.6	1.6	4.0	6.1	10.9	100.0
2	San Diego	B	16816	12.4	38.0	12.0	5.2	2.0	2.0	2.0	1.2	2.4	4.9	13.9	[2] 100.0
2	Orange	C	16817	.....	10.8	10.4	7.2	5.6	6.4	8.8	6.4	7.2	19.7	17.5	100.0
2	San Luis Obispo	E	16897A	4.4	26.4	14.0	8.8	4.8	4.4	5.2	2.0	6.4	13.0	10.6	100.0
2	do	E	16897B	4.4	25.9	14.8	9.2	4.8	5.2	5.6	2.4	6.4	12.9	8.4	100.0
2	Santa Barbara	A	16898	5.2	12.8	5.2	4.0	5.2	9.4	15.2	6.4	14.8	11.0	8.4	[3] 100.0
2	do	A	16899	6.0	12.0	3.2	3.0	4.2	8.0	15.0	7.2	18.2	14.6	8.6	100.0
26	Riverside	A	16900	.....	7.2	14.8	11.2	6.0	6.4	8.0	3.6	12.0	21.1	9.7	100.0
12	San Bernardino	B	16901	2.0	20.8	15.6	8.8	4.8	4.8	6.0	2.8	8.4	18.4	7.6	100.0
2	Santa Barbara	I	16902	3.6	32.0	16.0	8.8	3.6	4.0	4.4	2.0	5.6	10.7	9.3	100.0
2	Monterey	B	16903	2.4	30.4	16.0	7.6	3.6	3.6	4.4	2.0	4.8	15.4	9.8	100.0
2	San Benito	A	16904	1.6	30.8	14.0	7.2	3.2	3.6	4.4	2.4	7.2	18.4	7.2	100.0
2	Santa Clara	C	16905	8.0	37.2	14.4	5.6	2.4	2.4	2.8	1.6	5.6	12.8	7.2	100.0
2	Santa Barbara	H	17015	4.4	17.0	13.2	10.8	6.6	6.2	5.9	2.1	6.1	18.1	9.6	100.0
2	do	H	17016	5.0	15.9	13.4	12.4	7.9	7.2	5.9	2.0	5.2	14.2	10.9	100.0
2	do	H	17017	3.6	11.6	14.0	13.4	8.2	11.4	6.2	2.2	6.0	12.1	11.1	100.0
4	do	H	17018	7.0	20.8	11.6	9.6	5.9	5.6	5.2	1.9	5.5	17.5	9.4	100.0
4	Kern	C	17029	4.1	19.2	16.0	10.8	5.2	4.9	5.5	2.4	7.3	17.7	6.9	100.0
4	do	C	17030	.....	29.2	14.0	9.0	4.7	4.8	6.0	2.6	7.0	15.1	7.6	100.0
4	do	C	17031	1.8	21.2	11.6	11.6	7.1	7.4	7.6	3.0	8.0	10.7	10.0	100.0
4	do	C	17032	5.1	22.0	12.8	10.4	5.8	5.8	6.2	2.9	7.1	15.9	6.0	100.0
4	Los Angeles	D	17033	6.4	9.0	9.6	8.6	5.0	5.4	6.8	3.2	11.0	22.7	12.3	100.0
4	do	D	17034	.....	10.8	15.6	10.4	5.3	5.2	6.4	2.9	9.0	24.0	10.4	100.0
23	do	E	17035	7.0	37.2	12.8	6.0	2.8	3.7	3.9	1.8	5.4	6.3	13.1	100.0
23	do	C	17036	26.8	30.8	8.4	4.6	2.4	2.9	3.6	1.5	4.8	8.9	5.3	100.0
9	San Bernardino	B	17037	2.1	21.2	20.0	12.0	5.6	5.3	5.8	2.4	6.4	16.1	3.1	100.0
9	do	A	17038	1.5	16.8	12.0	8.8	5.4	6.1	7.8	3.4	9.8	19.8	8.6	100.0
9	do	A	17039	4.2	20.4	13.2	8.4	5.0	5.8	7.0	3.5	8.2	16.1	8.2	100.0
4	Los Angeles	B	17040	3.6	7.6	14.4	14.2	8.6	9.6	12.0	4.6	9.0	4.5	11.9	100.0
4	do	B	17041	4.2	9.0	14.0	14.0	8.8	9.6	11.4	4.5	9.2	7.0	8.3	100.0
4	do	B	17042	2.8	5.4	7.2	9.4	7.4	10.4	14.2	6.4	16.2	11.9	8.7	100.0

[1] Lab. Nos. 16898 and 16899 are modified Topeka; Nos. 17040, 17041, 17042 are Willite.
[2] 3.2 per cent passed 1 inch, retained ¾ inch; 0.8 per cent passed ¾ inch, retained ½ inch.
[3] 2.4 per cent passed ¾ inch, retained ½ inch.

WORK DONE.

The State highway system, shown in Plate III, on July 1, 1920, totaled 5,560 miles of roads. Of this mileage, 1,345.4 miles were completely graded and paved, and 337.1 miles were graded and not paved. In addition, 319.4 miles were in process of grading and not to be paved, and 206.8 miles were in process of paving with Portland cement concrete. Sixty-six miles of the pavement were reported to be reinforced.

Of the paving, 765 miles are built with Portland cement concrete unsurfaced (of which 47.6 miles are reinforced), 480.7 miles with Portland cement concrete surfaced three-eighths inch thick with bitumen, 53.9 miles with Portland cement surfaced with 1½-inch Topeka, 4.2 miles with Portland cement concrete surfaced with Willite, 0.9 mile with Portland cement concrete surfaced with Bitucrete, 6 miles with asphalti-

concrete on macadam, 0.9 mile with Willite on macadam, and 33.8 miles with oil macadam.[8]

The summary of construction proposed and done, as of July 1, 1920, under each separate bond issue is shown by the following tabulation:[9]

Bond issues.	Miles proposed.	Mileage actually constructed
1909	3,082.3	1,300
1915	679.71	550
1919	[1] 1,798.0	80
Total	5,560.01	[2] 1,930

[1] One hundred and thirty-four miles maintained under special appropriation roads.
[2] Mileages shown under various bond issues overlap in some instances due to the fact that separate contracts were let for grading and paving covering the same section of road or a portion thereof.

In the following tables, Table 2 shows, as of July 1, 1920, the details and costs of the survey, plan and construction work done and in progress, arranged by State divisions, routes, counties, and sections, and Table 3 gives a recapitulation. These tabulations are from the official records of the commission. Certain projects there shown were improved by contract and others by day labor; those done by day labor are indicated by the letter D in the column headed "Contract No." Following these tables are three tables which show in Table 4 a résumé of estimated costs and payments made for labor and materials on both contract and day-labor road-construction work by divisions to July 1, 1920; in Table 5, a similar statement for contract work only, and in Table 6, a similar statement for day-labor work only.

In Appendix B is shown a study in greater detail of 10 contract and 10 day-labor jobs selected from Table 2 which show the greatest percentage of increase in final cost over preliminary estimate.

The final total cost of the construction work shown as completed in Table 2 is in excess of the total of the engineer's preliminary estimates by $1,469,122, or an increase of 6.24 per cent. It should be borne in mind that while this work was in progress the cost of both labor and materials was increasing throughout the United States at the rate of approximately 20 per cent a year; in general this increase of labor and material costs in California is about the same as in other States.

The total cost of the completed work done by contract is $20,314,278; of that done by day labor, $4,679,529; while the totals of the corresponding preliminary estimates of cost are $19,652,768 and $3,871,917, respectively, which results in increases of 3.36 per cent and 20.86 per cent, respectively.

The total of payments for labor, materials, and construction equipment both on completed projects and those still in progress is $30,936,871, of which $22,209,249 is for contract work and $8,727,622 for day-labor work, which amounts are respectively 71.8 per cent and 28.2 per cent of the total. There are also charges for surveying, engineering, administration, etc., all of which are shown in the recapitulation of work-done schedule, Table 3. Certain of these charges should be prorated to contract and day-labor work in approximately the proportions given above and the results added to contract or day-labor totals as the case may be. For various reasons it is difficult to make an exactly just distribution of all these costs. For the purposes of this study, however, the equipment and construction yard items, except engineer equipment, have all been charged as construction costs against the day-labor work and the above mentioned indirect charges have been charged against contract and day-labor work in the proportions of 71.8 per cent and 28.2 per cent, respectively. With these additions, the total cost of contract work is $25,687,016, and of day-labor work, $10,093,542, and of both, $35,780,558. Thus there is an addition for surveys, engineering, equipment, and administration charges for contract work of 15.6 per cent, for day-labor work 15.7 per cent, and for both combined 15.65 per cent. This does not take into consideration the cost of equipment which is still serviceable. Assuming a value for the serviceable equipment of $400,000, and eliminating this amount, the above percentage for day labor becomes 15.88. The contract percentage becomes 15.85 and the combined percentage becomes 15.86. These percentages are very reasonable.

In addition to the $35,780,558 expended from highway and similar funds, it is appropriate here to state that $1,930,631 was spent from the motor-vehicle fund for "improvement," which is supplementary and additional construction.

Compilations from the work-done schedule, Table 2, show that the average cost per square yard of concrete pavement 4 inches in thickness and including all grading and structures, but not indirect charges and overhead, was: For 1913, $0.987; for 1914, $1.233; for 1915, $1.116; for 1916, $0.971; for 1917, $1.717; for 1918, $2.105; and for 1919, $2.065. From 1913 to 1916, inclusive, the concrete was laid in the proportions of 1:2½:5, and from 1917 to 1919, inclusive, 1:2:4 was used. The average for all years for 1:2½:5 concrete is $1.143, and for 1:2:4, $1.837. For three-eighth-inch oil top the cost per square yard was for 1915, $0.0883; for 1916, $0.0863; 1917, $0.0832; and for 1919, $0.0719. All of these costs seem very reasonable when compared with costs during the same period in other States.

The general progress of pavement and grading construction is shown by years on the several maps of Plates V to XII, inclusive.

[8] Much of the work of construction and surfacing with oil top, etc., done by the State after July 1, 1920, was classified, and, consequently, corresponding differences appear in the tables on classification.
[9] Figures do not include contracts for surfacing only.

TABLE 2.—*Construction and costs.*

DIVISION I.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
248	Del Norte	1	B	Last Chance Slide	Cushion Creek	7.73	Grading				July 23, 1919			$217,394	$114,974	$14,666			
265	do	1	B	Cushion Creek	Crescent City	4.08	do				Jan. 23, 1920			33,761	9,510	607			
	do	1	B			3.19	Surveyed												
	do	1	A			13.50	do												
	do	1	C			17.00	do												
	do	1	D			8.00	do												
	do	1	E			18.00	do												
	do					59.69	Surveyed total										$30,766	$158	
44	Humboldt	1	A	Garberville	SE. ¼ sec. 1, T. 5 S., R. 3 E.	5.48	Grading				Oct. 29, 1913	Oct. 20, 1914	100	62,236	52,653	2,462			
60	do	1	A	T. 5 S., R. 3 E.	Southerly boundary.	4.58	do				Apr. 22, 1914	Nov. 24, 1914	100	61,964	64,725	1,984			
D-245	do	1	A	Approach for South Fork Branch.			do				Aug. 15, 1919	Oct. 15, 1919	100	1,740	1,762	34			
211	do	1	B	Garberville	Miranda	15.61	do				Nov. 19, 1917	Sept. 23, 1919	100	250,872	270,752	14,133			
D-250	do	1	B	Station 370 plus 00	Station 850 plus 00	4.95	Graveling				Sept. 3, 1919	Jan. 15, 1920	100	13,000	12,998				
D-269	do	1	B	Dean Creek	Station 948 plus 00		Bridges				Oct. 15, 1919			16,225	5,703	25			
93	do	1	C	Miranda	Dyerville	13.75	Grading				Aug. 11, 1914	Sept. 16, 1915	100	160,844	161,062	7,034			
71	do	1	D	Dyerville	Shively	7.23	do				June 9, 1914	Feb. 25, 1915	100	93,895	102,669	5,622			
104	do	1	D	Shively	Jordan Creek	3.70	do				Oct. 6, 1914	Aug. 24, 1915	100	45,717	38,923	2,225			
D-155	do	1	D	Station 0 plus 00	Station 13 plus 00	.25	do				Sept. 13, 1917	Jan. 12, 1918	100	3,220	4,628				
136	do	1	E	Jordan Creek	Rio Dell	6.86	do				June 2, 1915	Feb. 11, 1916	100	85,750	68,254	3,556			
166	do	1	E	Eel River bridge near Scotia.		.19	Steel bridge				Apr. 25, 1916	Jan. 23, 1917	100	114,991	121,173	1,214			
205	do	1	F	Rio Dell	Fortuna	6.59	Grading				Sept. 18, 1917	Aug. 26, 1918	100	54,063	47,157	3,258			
D-27	do	1	F	2½ miles north of Rio Dell.	¼ mile south of Alton.	.82	do				Dec. 31, 1913	July 13, 1915	100	7,468	12,626	864			
D-216	do	1	F	Van Dusen Creek bridge extension.		.15	Timber bridge				Feb. 21, 1919	Aug. 1, 1919	100	1,500	1,161				
105	do	1	G	Loleta	Beatrice	4.30	Grading				Oct. 6, 1914	May 8, 1915	100	31,359	24,307	2,160			
169	do	1	G	do	do	4.30	15-foot concrete base.	4½		1–2½–5	July 10, 1916	Jan. 23, 1917	100	42,806	36,932	5,420			$41,552 paid from motor-vehicle fund.
240	do	1	G	Eureka Slough bridge.		.13	Timber bridge				Mar. 14, 1919	Apr. 22, 1920	100	84,710	77,625	2,696			
D-275	do	1	G	Beatrice	Eureka	7.94	15-foot concrete base.	5		1–2–4	Oct. 15, 1919			162,288	30,363	2,695			
	do	1	G			3.80	Surveyed												
220	do	1	H	Eureka	Arcato	6.17	Grading				Mar. 13, 1918			87,501	91,631	8,089			
	do	1	J			15.60	Surveyed												
249	do	1	J	Fresh-water lagoon	Orick	2.80	Grading				Aug. 8, 1919			35,883	37,682	3,531			
	do	1	J			24.70	Surveyed												
	do	1	K			18.70	do												
	do					62.80	Surveyed, total										79,218	656	
D-309	do	20	G	Redwood Creek	Three Creeks	12.77	Grading				Feb. 26, 1920			255,659	27,207	1,688			
	do	20	G			.23	Surveyed										20,203	376	
	Lake	15	A			9.45	do										3,823	83	
253	do	16	A	Westerly boundary	Lakeport	9.36	Grading				Sept. 26, 1919			108,022	85,902	6,079			
	do						Surveyed, total										5,531	281	
2	Mendocino	1	A	Southerly boundary	Hopland	12.91	Grading				July 23, 1912	Aug. 27, 1913	100	70,508	93,280	2,675			
87	do	1	B	Hopland	Ukiah	11.40	15-foot concrete base.	4		1–2½–5	do	Oct. 5, 1915	100	112,423	94,223	8,164			
D-113	do	1	B	4 miles south of Ukiah.	do	4.06	Oiled surface		⅜			Nov. 15, 1916	100	4,039	3,699	30			
24	do	1	C	Ukiah	Forsythe Creek	7.73	Water-bound macadam, oil surface.	6–7	⅜		Mar. 26, 1913	June 23, 1914	100	64,035	78,748	5,419			
57	do	1	D	Forsythe Creek	Ridgewood	6.55	Grading				Apr. 22, 1914	Apr. 30, 1915	100	64,192	59,904	5,027			
D-4	do	1	D	do	do	1.24	do					Dec. 15, 1914	100	10,406	16,646	1,029			
D-302	do	1	D	do	Ridgewood - Van Arsdale Road.	7.79	do				Feb. 6, 1920			47,200	3,322	202			
20	do	1	E	Ridgewood	Willits	6.84	do				Feb. 4, 1913	Dec. 1, 1914	100	37,340	39,138	3,415			
D-277	do	1	E	Willits			Temporary garage				Oct. 23, 1919	Nov. 8, 1919	100	3,430	3,406				Paid from motor-vehicle fund.

TABLE 2.—*Construction and costs*—Continued.

DIVISION I—Continued.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
D-303	Mendocino	1	E	Ridgewood-Van Arsdale.	Willits	6.85	Grading				Feb. 6, 1920			$11,300	$11,213	$479			
215	do	1	F	Willits	Arnold	8.24	do				Dec. 19, 1917	Dec. 10, 1918	100	95,266	128,878	5,504			
232	do	1	F	Outlet Creek			Concrete bridge				July 19, 1918	Jan. 9, 1919	100	13,665	14,525	203			
D-208	do	1	G	Arnold	Sherwood-Laytonville.	10.19	Grading							114,085	233,206	6,860			
D-195	do	1	H	Sherwood Junction	Rattlesnake Summit.	13.76	do				June 7, 1918			154,790	175,615	7,648			
D-56	do	1	I-J-K	Rattlesnake Summit	Northerly boundary	33.11	do				Aug. 1, 1915			579,443	699,541	26,395			
	do						Surveyed total										$68,807	$1,570	
	do	15	A			13.06	Surveyed										4,341	70	
247	do	16	A	Hopland	Easterly boundary	9.74	Grading				July 3, 1919			108,498	133,417	7,991			
	do						Surveyed, total										6,101	190	
	do	48	C			13.00	Surveyed										10,963	173	
D-301	do			Willits			Office building				Apr. 5, 1920			12,365	7,261	1			
D-290	do			do			Maintenance yard				Nov. 13, 1919			5,550	4,741	5			Paid from motor-vehicle fund.
	Totals, Division I.													3,541,403	3,303,142	171,089	229,753	3,557	

DIVISION II.

	Lassen	28	A			15.80	Surveyed										$2	$2	
D-117	do	29	B	Near Susanville		1.00	Grading				Jan. 29, 1917	Feb. —, 1917	100	$500	$775				
226	do	29	B	Copperville	Susanville	14.90	do				July 2, 1918			79,804	45,744	$5,227			
D-323	do	29	B	do	do	15.00	Gravel surfacing				Apr. 2, 1920			69,000	1,936				
	do	29	C			11.70	Surveyed												
	do	29	D			30.30	do												
	do	29	E			11.00	do												
	do					52.73	Surveyed, total										7,095	278	
200	Shasta	3	A	Cottonwood Creek bridge.		.11	Concrete bridge				Aug. 28, 1917	Feb. 4, 1920	100	54,136	71,179	5,286			
D-281	do	3	A	Cottonwood Creek bridge approach.			Grading				Nov. 6, 1919			3,540	2,185	57			
	do	3	A			15.60	Surveyed										59,821	301	
144	do	3	B	Pitt River bridge		.07	Concrete bridge				July 20, 1915	May 12, 1916	100	37,149	36,975	1,426			
203	do	3	B	Redding	Bayha	10.83	Grading				Sept. 11, 1917	Aug. 26, 1918	100	58,192	69,515	11,198			
225	do	3	B	Sulphur, Boulder, Salt, Moody, Bayha Springs, and Churn Creeks.		.09	Concrete bridge				July 2, 1918	Aug. 13, 1919	100	35,145	35,753	3,414			
D-47	do	3	B	Approach to Sacto River Bridge at Redding.		.09	Grading				June 25, 1915	Aug. 14, 1915	100	2,760	3,086	183			
85	do	3	B-C	Bayha	Sacramento River	16.21	do				July 21, 1914	Oct. 5, 1915	100	185,368	232,542	20,524			
174	do	3	C	Salt Creek and Sacto River bridges.		.13	Concrete bridges				July 28, 1916	Apr. 3, 1917	100	38,978	40,013	1,123			
199	do	3	C	Sacramento River	Lamoine	13.31	Grading				Aug. 27, 1917	Nov. 6, 1919	100	178,967	205,573	22,004			
D-219	do	3	C	Slate and Dorey Creek bridges.			Reinforced concrete bridges.				Feb. 27, 1919	Sept. 19, 1919	100	13,685	14,194	59			
D-280	do	3	C-D	764-78 sec. C	Northerly boundary.	24.60	Gravel surface				Oct. 23, 1919			25,000	26,386	380			
75	do	3	D	Lamoine	Hazel Creek	9.92	Grading				June 9, 1914	Oct. 5, 1915	100	72,516	99,687	11,244			
145	do	3	D	Boulder and Shotgun Creek bridges.		.13	Concrete bridges				July 20, 1915	Jan. 25, 1916	100	8,390	9,108	672			
187	do	3	D	Hazel Creek	Northerly boundary.	11.28	Grading				June 6, 1917	Nov. 16, 1919	100	155,931	178,715	18,053			
224	do	3	D	Castle, Mears, and Plume Creeks.		.04	Concrete bridges				May 16, 1918	Apr. 21, 1919	100	20,454	18,873	1,033			

D-83	.....do.....	3	D	Boulder and Shotgun Creeks.			Grading				Nov. 10, 1915	Dec. 19, 1916	100	200	360	14			
	.....do.....	20	A-B			10.06	Surveyed										16,323	340	
241	.....do.....	20	A-B	Towerhouse	Redding	15.94	Grading				Apr. 12, 1919			195,312	165,769	14,670			
D-266	.....do.....	20	A-B	.....do.....	.....do.....		Grading gravel surface.				Oct. 15, 1919			43,000	26,691	379			
D-327	.....do.....	20	A-B	Whiskey and Salt Creek bridges and station 506.			Grading				Apr. 20, 1920			1,053	810	46			
	.....do.....	28	A			22.00	Surveyed												
	.....do.....	28	B			13.50	.....do.....												
	.....do.....	28	C			20.00	.....do.....												
	.....do.....					55.50	Surveyed, total										29,724	387	
D-328	.....do.....			Redding			Maintenance building.				Jan. 10, 1920			6,156	4,000				Paid from motor-vehicle fund.
D-236	Modoc.....	28	A	Adin Summit	Canby	10.85	Grading				May 28, 1919			74,561	59,909	2,112			
D-341	.....do.....	28	B	Canby	Alturas	17.11	.....do.....				May 24, 1920			207,635					
	.....do.....						Surveying										4,467	75	
100	Siskiyou.....	3	A	Weed	Dunsmuir	16.60	Grading				Sept. 22, 1914	Dec. 21, 1915	100	79,705	94,761	9,344			
155	.....do.....	3	A	Dunsmuir Bridge		.10	Concrete bridges				Aug. 24, 1915	Nov. 21, 1916	100	44,473	45,418	1,665			
235	.....do.....	3	A	Dunsmuir	Southerly boundary.	1.52	Grading				Sept. 10, 1918	Aug. 13, 1919	100	15,273	24,237	1,207			
D-74	.....do.....	3	A	Southern city limits, Dunsmuir.	.....do.....	1.30	.....do.....				Aug. 2, 1917	May 19, 1918	100	3,500	9,418	820			
180	.....do.....	3	A-B	Greenhorn, Yreka, and Little Castle Creeks.		.04	Concrete bridges				May 22, 1917	Dec. 19, 1917	100	11,475	10,013	794			
D-169	.....do.....	3	B	Greenhorn, Yreka Creek bridges.			Grading				Oct. 22, 1917	Jan. 19, 1918	100	4,000	2,183	57			
D-232	.....do.....	3	B	Weed	Gazelle	10.78	.....do.....				May 8, 1919			113,740	88,209	5,292			
	.....do.....	3	B			17.62	Surveyed										36,436	458	
66	.....do.....	3	C	Hornbrook	Oregon line	8.03	Grading				May 27, 1914	Sept. 16, 1915	100	35,609	44,195	8,770			
118	.....do.....	3	C	.....do.....	Yreka	16.92	.....do.....				Dec. 22, 1914	Dec. 21, 1915	100	135,746	146,699	23,439			
D-99	.....do.....	3	C	Yreka	Oregon line	.25	.....do.....				Mar. 16, 1916	Apr. 22, 1916	100	3,200	3,129	35			
D-152	.....do.....	3	C	Oregon line	4½ miles south	4.50	Gravel surface				Aug. 2, 1917	July 19, 1918	100	42,000	42,132	500			
	.....do.....	46	B			20.00	Surveyed												
	.....do.....	46	C			23.00	.....do.....												
	.....do.....	46	D			22.00	.....do.....												
	.....do.....					65.00	Surveyed, total										15,389	292	
260	Tehama.....	3	A	Southerly boundary.	Los Malinos	11.72	15-foot concrete base.	4		1-2 -4	Jan. 2, 1920			278,014	86,123	3,193			
D-235	.....do.....	3	A	Toome and Champlin Creeks.			Grading				June 11, 1919			2,500	1,920	132			
D-252	.....do.....	3	B	Approaches to Rodeo, Elder, Jackson, Oat Creek bridges.		.25	15-foot concrete base.	5		1-2 -4	Sept. 23, 1919			7,400	7,033	538			
135	.....do.....	3	B	Proberta	Red Bluff	6.38	.....do.....	4		1-2½-5	June 1, 1915	Oct. 11, 1916	100	58,877	57,333	4,633			
162	.....do.....	7-3	A-B	Corning	Proberta	9.75	.....do.....	4		1-2½-5	Jan. 11, 1916	Oct. 10, 1917	100	105,531	80,771	7,569			
142	.....do.....	3	C	Red Bluff	Northerly boundary.	12.74	Grading				July 20, 1915	Jan. 11, 1916	100	59,573	51,179	5,231			
D-320	.....do.....	3	C	End of L. O. 170	.....do.....	1.14	.....do.....				Mar. 23, 1920			7,955	2,601	80			
	.....do.....	3	D			15.50	Surveyed										21,894	474	
76	.....do.....	7	A	Southerly boundary.	Corning	8.81	15-foot concrete base.	4		1-2½-5	June 9, 1914	June 22, 1915	100	79,898	76,574	5,428			
D-81	.....do.....	7	A	.....do.....	.....do.....	3.23	Oil surface		⅜			Dec. 25, 1915	100	4,825	3,091	502			
D-251	.....do.....	7	A	Approaches to McClure and Truckee Creeks.		.07	15-foot concrete base, retaining wall.	5		1-2 -4	Sept. 23, 1919			2,803	2,455	131			
	.....do.....						Surveying										3,366	39	
	.....do.....	29	A			22.00	Surveyed												
	.....do.....	29	C			23.00	.....do.....												
	.....do.....					45.00	Surveyed, total										21,746	619	
	Trinity.....	20	A			13.00	Surveyed												
	.....do.....	20	B			11.00	.....do.....												Built by Forest Service.
	.....do.....	20	C																
	.....do.....	20	D			17.00	Surveyed												
242	.....do.....	20	E	Whites Bar Creek	Helena	11.40	Grading				June 18, 1919			290,848	156,213	10,209			
	.....do.....	20	F			21.00	Surveyed										40,167	150	
	Totals, Division II.													2,954,377	2,385,465	208,683	256,430	3,415	

TABLE 2.—*Construction and costs*—Continued.

DIVISION III.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
	Amador	34	A			5.90	Surveyed												
	do	34	B			10.70	do												
	do					16.60	Surveyed, total										$8,730	$288	
	do	54	A			10.70	Surveyed										2,708	57	
207	Butte	3	A	Southerly boundary.	Biggs	7.68	15-foot concrete base.	4		1-2 -4	Oct. 17, 1917	Aug. 13, 1919	100	$77,534	$107,469	$7,469			
D-241	do	3	A	Station 199 plus 50	Station 200 plus 50.	.02	do	4		1-2 -4	July 18, 1919	Sept. 6, 1919	100	305	368				
D-196	do	3	B	Biggs	Nelson	12.70	do	4-6		1-2 -4	July 31, 1918			483,643	421,007	10,136			
122	do	3	C	Nelson	Chico	12.77	do	4-6		1-2½-5	Feb. 9, 1915	Sept. 26, 1916	100	142,956	136,901	6,462			
D-92	do	3	C	Fourth Street, Chapmantown.	Little Chico Creek.	.40	do	4		1-2½-5	Dec. 18, 1915	Mar. 21, 1916	100	5,340	3,658	514			
D-202	do	3	C	South approach to Butte Creek bridge.		.02	do	4		1-2 -4	Mar. 26, 1919	Aug. 30, 1919	100	250	718				
	do	3	C			.21	Surveyed												
70	do	3	D	Lindo Channel	Northerly boundary.	12.70	15-18-foot concrete base.	4-5		1-2½-5	June 9, 1914	Jan. 11, 1916	100	115,342	128,519	7,856			
D-87	do	3	D	Chico	do	12.66	Oil surfacing		⅜		Dec. 4, 1915			11,413	22	7			
	do						Surveying										13,328	144	
	do	21	A			.32	Surveyed												
227	do	21	A	Oroville	Shippee Road	6.38	15-foot concrete base.	4		1-2 -4	July 2, 1918	Dec. 15, 1919	100	100,933	143,778	7,602			
D-284	do	21	A	Borings at Feather River bridge.			Borings				Nov. 16, 1919	Jan. 3, 1920	100	2,179	1,884	691			
	do	21	C				Surveying										18,739	99	
	do	30					do										1,192	54	Quincy lat.
	do	47	A			8.50	do										1,751	8	
228	Calaveras	24	A	Westerly boundary	Valley Springs	10.00	Grading				July 2, 1918	Aug. 13, 1919	100	54,427	70,339	6,193			
D-263	do	24	A	do	do	10.00	Gravel surfacing				Sept. 23, 1919			25,000	8,974				
D-104	do	24	B	Valley Springs	San Andreas	10.00	Grading				May 11, 1916	Apr. 27, 1918	100	62,000	59,743	970			
	do						Surveying										9,797	320	
80	Colusa	7	A	Hershey	Berlin	10.97	15-foot concrete base.	4		1-2½-5	June 23, 1914	Dec. 21, 1915	100	99,154	113,495	6,936			
151	do	7	A	Through Arbuckle		.31	22.5-foot Topeka surface.		1½		Aug. 10, 1915	Nov. 9, 1915	100	5,879	5,687	216			
D-69	do	7	A	Hershey	Arbuckle	6.92	Oil surfacing		⅜			Oct. 30, 1915	100	6,089	2,597	168			
99	do	7	B	Berlin	Colusa Junction	12.67	15-foot concrete base.	4		1-2½-5	Sept. 10, 1914	Aug. 24, 1916	100	122,175	138,541	7,926			
D-203	do	7	B	Railroad crossing, Colusa & Lake R. R.		.01	do	4		1-2 -4	Mar. 26, 1919	Nov. 29, 1919	100	60					
D-256	do	7	B	Berlin	Colusa Junction	8.73	Oiling		⅜		Sept. 23, 1919			11,131	6,808	74			
139	do	7	C	Colusa Junction	Northerly boundary.	10.67	15-foot concrete base.	4		1-2½-5	June 22, 1915	Aug. 24, 1916	100	92,150	97,347	4,110			
D-204	do	7	C	Station 222 (exc.)		.03	do	4		1-2 -4	Mar. 26, 1919	Oct. 19, 1919	100	511	621	181			
D-255	do	7	C	Colusa Junction	County line	10.73	Oiling		⅜		Sept. 23, 1919			14,003	1,651	31			
	do						Surveying										6,776	57	
117	do	15	A	Williams	Colusa	8.44	15-foot concrete base.	4-5		1-2½-5	Dec. 22, 1914	July 21, 1915	100	93,058	106,081	5,580			
D-257	do	15	A	do	do	6.74	Oiling		⅜		Sept. 23, 1919			10,000	5,891	84			
	do	15	A			.26	Surveyed												
	do	15	B			7.70	do												
	do					7.96	Surveyed, total										6,288	122	
D-173	El Dorado	11	A	White Rock	Shingle Springs	10.28	12-foot concrete base.	4		1-2 -4	Nov. 28, 1917	July 26, 1919	100	121,132	252,008	6,929			
D-2	do	11	B	Shingle Springs	El Dorado	5.27	12-foot oil macadam.	6		(1)	Aug. 27, 1913	July 31, 1915	100	25,619	97,392	4,628			
D-5	do	11	C	El Dorado	Placerville	6.57	12-foot concrete base, oil surface.	4	⅜	1-2½-5	Apr. 22, 1914	July 26, 1915	100	61,291	160,375	4,827			
	do	11	D			16.60	Surveyed												
	do	11	E			8.40	do												
	do	11	K			5.30	do												
	do					30.30	Surveyed, total										17,704	214	
113	Glenn	7	A	Southerly boundary.	Willows	8.59	15-foot concrete base.	4		1-2½-5	Nov. 20, 1914	Aug. 24, 1916	100	76,579	75,456	5,871			
D-259	do	7	A	County line	do	4.58	Oiling		⅜		Sept. 23, 1919			6,169	3,335	100			

140	do	7	B	Willows	Grapit	9.43	15 foot concrete base.	4		1-2½-5	July 7, 1915	Apr. 18, 1916	100	84,094	79,844	4,504			
	do	7	B	do	do	10.44	Oiling		⅜		Sept. 23, 1919			14,144	7,735	8			
D-258	do	7	B	do	do	1.04	15-foot concrete base, bridge.	4		1-2½-5	July 10, 1916	Dec. 19, 1916	100	17,266	13,866	960			
172	do	7	B	At Walker Creek		.04	15 and 21 foot concrete base.	4		1-2 -4	Mar. 26, 1919	Oct. 16, 1919	100	760	902	158			
D-205	do	7	B	Walker Creek bridge approaches.		6.96	15-foot concrete base.	4		1-2½-5	June 9, 1914	Jan. 12, 1915	100	56,240	58,163	2,755			
77	do	7	C	Grapit	Northerly boundary.	6.94	Oil surfacing		¾			Dec. 4, 1915	100	6,300	4,393	243			
D-70	do	7	C	do	do		Surveying										5,625	77	
	do					10.30	Surveyed										1,405	9	
	do	47	A			9.12	Stock-piling material.				Oct. 23, 1919	Dec. 6, 1919	100	1,500	1,500	14			
D-283	Nevada	17	A	Southerly boundary.	Rattlesnake Creek	14.82	Grading and 15-foot concrete base.	4		1-2 -4	Nov. 19, 1917	Dec. 15, 1919	100	191,276	201,022	12,966			
209	do	17	A-B	do	Nevada City												14,182	516	
	do	17	A-B			3.08	Surveyed												
D-175	do	25	A	Nevada City	Northerly boundary.	18.00	Grading				Dec. 28, 1917			17,000	122,344	379			
	do				do		Surveying										14,985	245	
	do					6.80	Surveyed												
	do	15	A			7.20	do										3,720	100	
	do	15	B			14.00	Surveyed, total										7		
	do																		
	do	37				9.90	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Sept. 25, 1912	June 23, 1914	100	84,586	94,181	8,185			
13	Placer	3	A	Southerly boundary.	Lincoln	0.12	Sub. and concrete base approach.	4		1-2½-5	Apr. 18, 1916	Sept. 26, 1916	100	12,255	8,270	920			
165	do	3	A	Andora underpass		8.57	15-foot concrete base.	4		1-2½-5	Nov. 9, 1915	Dec. 19, 1916	100	89,392	82,407	5,627			
156	do	3	B	Lincoln	Northerly boundary.		Grading					July 27, 1917	100	499	388	306			
D-144	do	3	B	Yankee Slough bridges (1 and 2).		0.44	15 and 21 foot concrete base.	4		1-2 -4	Mar. 26, 1919	Aug. 16, 1919	100	7,020	6,283	873			
D-200	do	3	B	Ahart, Ew. and Yank Slough bridge.													7,880	37	
	do	3	B			0.39	Surveyed												
168	do	17	A	Roseville	Penryn	7.52	15-foot concrete base.	4		1-2½-5	July 10, 1916	June 6, 1917	100	73,967	63,964	4,040			
	do	17	A	Through Rocklin		1.45	do	4		1-2 -4	Mar. 6, 1919	Jan. 3, 1920	100	23,000	24,837	2,168			
D-220	do	17	A	Station 452 plus 47	Station 524	1.35	do	4		1-2 -4	Aug. 5, 1919	Apr. 17, 1920	100	24,500	19,848	1,645			
D-247	do	17	A	Penryn	Auburn	6.48	do	4		1-2½-5	Jan. 11, 1916	Feb. 6, 1917	100	70,007	67,633	4,901			
164	do	17	B			6.70	Surveyed										15,097	161	
	do	17	C			7.90	do										1,884		
	do	37	A				do										16		
	do	38	B-C				do												
	Plumas	21	A			27.00	do										1,094		
	do	21	B-C			34.90	Surveyed, total										23		
	do					21.00	Surveyed										2,603	13	
	do	29	C																
	do	30				1.85	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Sept. 25, 1912	Feb. 26, 1914	100	13,173	15,714	2,730			
12	Sacramento	3	A	Auburn Road	Northerly boundary.												2,794	55	
	do	3	B			12.30	Surveyed												
	do	4	A			7.40	do												
	do	4	B			14.60	do										1,692	89	
	do					22.00	Surveyed, total												
	do	11	A	Folsom	Easterly boundary	6.83	12-foot concrete base.	4		1-2½-5	Nov. 10, 1914	Nov. 9, 1915	100	63,131	64,490	4,322			
D-71	do	11	A	do	do	6.83	Oil surfacing		⅜			Jan. 15, 1916	100	4,790	6,241	93			
D-222	do	11	B	Through Folsom		0.27	15-foot concrete base.	4		1-2 -4		May 20, 1918	100	2,640	2,447				
	do	11	B			17.33	Surveyed										4,818	75	
	do	34	A			8.50	do										3,085	79	
D-109	do		Spec'l	State fair grounds, Sacramento.		0.14	Demonstration road.	4		1-2½-5		Sept. 9, 1916	100		560	75	60		
D-293	do			Sacramento			Maintenance building and shop site.				Dec. 15, 1919	Apr. 24, 1920	100	17,800	17,659	20			
D-279	San Joaquin	4	A	Stanislaus River bridge.		0.25	Topeka surface		4		Oct. 23, 1919	Jan. 10, 1920	100	3,000	2,657	136			
D-238	do	4	A	Calla	Manteca	2.60	15-foot concrete base.	5		1-2 -4	July 18, 1919			68,290	59,853	1,694			
	do	4	A			4.65	Surveyed												
D-239	do	4	B	Manteca	Stockton	0.60	15-foot concrete base.	4		1-2 -4	July 18, 1919	Apr. 17, 1920	100	12,331	10,661	171			
	do	4	B			10.50	Surveyed												
	do	4	C			14.80	do												
256	do	4	D	Houston School	Northerly boundary.	4.72	8 and 15-foot concrete base.	5		1-2 -4	Oct. 7, 1919			103,321	82,629	3,424			
	do	4	D			0.58	Surveyed										7,779	150	
	do					30.53	Surveyed, total												

[1] Macadam.

TABLE 2.—*Construction and costs*—Continued.

DIVISION III—Continued.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
	San Joaquin	5	A			8.80	Surveyed												
D-240	do	5	B	Banta	French camp	2.50	15-foot concrete base.	4		1-2 -4	July 18, 1919	June 5, 1920	100	$63,510	$58,344	$1,882			
D-262	do	5	B	Paradise Cut bridge		0.36	Grading				Sept. 23, 1919	Oct. 7, 1919	100	1,400	1,120				
	do	5	B			9.74	Surveyed												
	do					18.54	Surveyed, total										$5,305	$166	
	do	24					Surveyed										3,470	94	
D-116	Sierra	25	A	Westerly boundary	Downieville	8.00	Grading				Jan. 25, 1917			61,000	146,047	4,129			
D-261	do	25	A	North Fork of Yuba River.			Steel bridge				Sept. 23, 1919			16,242	13,504				
	do	25	A			9.00	Surveyed										8,128	74	
79	Solano	7	A	Benicia	2½ miles south Cordelia.	9.05	15-foot concrete base.	4-6		1-2½-5	Mar. 25, 1916	June 9, 1914	100	104,883	95,013	7,922			
D-271	do	7	A	do	do	9.05	Oil surfacing		⅜		Oct. 15, 1919			11,104		1			
114	do	7	B	2½ miles south of Cordelia.	Fairfield	8.13	15-foot concrete base.	4		1-2½-5	Nov. 20, 1914	Oct. 5, 1915	100	78,022	71,668	3,951			
D-60	do	7	B	do	do	8.06	Oil surfacing		⅜			Oct. 2, 1915	100	7,121	4,050	149			
D-126	do	7	B	Suisun Creek and station 790.		.07	15-foot concrete, base, concrete bridge.	4		1-2 -4	May 2, 1917	Aug. 4, 1917	100	5,000	6,622	454			
74	do	7	C	Fairfield	Vacaville	8.83	15-foot concrete base, oil surfacing.	4-6	⅜	1-2½-5	June 9, 1914	July 7, 1915	100	100,995	98,450	5,319			
	do	7	C			.07	Surveyed												
111	do	7	D	Vacaville	Batavia	8.24	15-foot concrete base.	4-6		1-2½-5	Nov. 10, 1914	Jan. 11, 1916	100	75,749	84,253	5,582			
D-270	do	7	D	do	Near Batavia	8.17	Oil surfacing		⅜		Oct. 15, 1919			9,651	233				
	do	7	D			.06	Surveyed												
186	do	7	E	Batavia	Putah Creek	8.35	15-foot concrete base.	4		1-2 -4	June 6, 1917	Aug. 26, 1918	100	84,773	88,548	6,195			
D-272	do	7	E	Near Batavia	Northerly Boundary.	8.35	Oil surfacing		⅜		Oct. 15, 1919			9,995					
	do	7	E			.05	Surveyed												
	do						Surveying, total										11,719	92	
183	do	8	A	Westerly boundary	Cordelia	3.45	15-foot concrete base.	4-4½		1-2 -4	May 22, 1917	Jan. 9, 1919	100	52,908	54,898	6,227			
D-212	do	8	A	do	do	.44	Guardrail				Dec. 27, 1918	Apr. 1, 1919	100	1,414	1,478	225			
	do						Surveying, total										2,262	31	
	do	53	A			9.40	Surveyed												
	do	53	B			12.00	do												
	do					21.40	Surveyed, total										4,222	92	
5	Stanislaus	4	A	Southerly boundary	Ceres	12.04	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Aug. 27, 1912	Sept. 22, 1913	100	82,708	89,225	4,290			
D-189	do	4	A	At Turlock city limits.			Asphalt concrete	5½			Apr. 10, 1918	Apr. 5, 1918	100	250	217				
25	do	4	B	Ceres	Northerly boundary.	9.61	15-foot concrete base, oil surfacing.	4		1-2½-5	Mar. 26, 1913	June 23, 1914	100	72,885	70,450	7,551			
D-122	do	4	B	Tuolumne River bridge.		.02	15-foot concrete base.				Mar. 21, 1917	Apr. 1, 1917	100	525	461				
	do	4	B			.17	Surveyed												
	do						Surveying, total										6,933	158	
222	do	13	A	At river bank		.69	12-foot concrete base, bridge.	4-6½		1-2 -4	Apr. 10, 1918	Oct. 30, 1918	100	22,482	24,601	1,154			
D-50	do	13	A	Salida	Oakdale	13.81	12-foot concrete base.	4		1-2½-5		June 10, 1916	100	108,393	102,567	5,258			
D-286	do	13	A	Bald Eagle ranch	do	5.00	Concrete shoulders				Nov. 6, 1919			34,000	25,931	1,689			
D-29	do	13	B	Knights Ferry road	Easterly boundary.	1.32	Grading				Oct. 20, 1919	Oct. 9, 1915	100	7,110	6,594	139			
254	do	13	B	Oakdale	do	12.79	15-foot concrete base.	4		1-2 -4	Oct. 1, 1914			242,109	126,934	5,561			
	do						Surveying, total										6,126	109	
121	Sutter	3	A	Yuba City	Northerly boundary.	11.70	15-foot concrete base.	4		1-2½-5	Jan. 19, 1915	Jan. 11, 1916	100	98,233	96,144	5,438			

	do							Surveying, total									2,408	13	
	do	15	A			8.10		Surveyed											
	do	15	B			5.95		do									4,372	35	
	do					14.05		Sueveyed, total											
D-6	Tuolumne	13	A	Western boundary	Keystone	10.84		Grading						June 12, 1915	100	48,548	71,079	2,687		
D-253	do	13	A-B	do	Sonora			Stock-piling aggregate					Sept. 11, 1919			30,000	36,646	1,131		
D-33	do	13	B	Keystone	do	11.01		Grading					Mar. 26, 1915	Mar. 11, 1916	100	55,070	45,376	2,640		
	do	18	A			5.40		Surveyed											40	1
124	Yolo	6	A	Davis	Yolo by-pass	4.80		18-foot concrete base	[2] 5¼		1-2½-5		Apr. 6, 1915	Feb. 11, 1916	100	98,648	86,410	5,832		
								Oil surfacing		⅜			July 1, 1916	July 1, 1916	100	5,062	5,398	151		
D-68	do	6	A	do	Webster	4.29		18-foot concrete base	[2] 5¼		1-2½-5		Mar. 10, 1916	Apr. 22, 1916	100	5,574	4,853	122		
D-98	do	6	A	Station 104 plus 14	Station 121 plus 62	.41		Gravel surface					May 17, 1916	June 29, 1916	100	57	20			
D-105	do	6	A	Station 348 plus 50				18-foot concrete base subway	4–10		1-2 –4		July 9, 1917	Jan. 18, 1918	100	17,535	20,843	1,704		
D-147	do	6	A	Davis subway		.23		15-foot concrete base	[2] 5¼		1-2 –4		Aug. 3, 1917	Mar. 9, 1918	100	12,644	18,450	1,215		
D-148	do	6	A	Approach to Yolo trestle		.90		Oil surfacing		⅜			Oct. 15, 1919			2,909				
D-273	do	6	A	Davis	Yolo trestle	2.06		Concrete bridge					July 21, 1914	Apr. 25, 1916	100	396,552	404,440	18,638		
86	do	6	B	Across Yolo by-pass		3.13		Bascule bridge					Dec. 7, 1915	Sept. 18, 1917	100	30,655	28,159	2,784		
160	do	6	B	do		.03		18-foot concrete base	[2] 5¼		1-2½-5		Apr. 16, 1915	May 22, 1916	100	59,027	49,918	3,799		
127	do	6	C	Yolo by-pass	Sacramento River	3.69		Oil surfacing		⅜			July 1, 1916	July 1, 1916	100	3,791	2,247			
D-102	do	6	C	do	Sacramento-Woodland R. P.	3.70		15-foot concrete base	[2] 5¼		1-2 –4		Aug. 3, 1917	June 15, 1918	100	16,558	22,015	1,059		
D-149	do	6	C	Approach to Yolo trestle		1.13		Oil surfacing		⅜			Oct. 15, 1919			1,610				
D-274	do	6	C	Yolo trestle	Sacramento	1.13		Surveying, total											9,890	1,364
	do							Oil surfacing		⅜			Oct. 9, 1915	Oct. 9, 1915	100	11,373	3,026	201		
D-67	do	6–7	A	Southerly boundary	Woodland	12.91		15-foot concrete base	4		1-2½-5		July 7, 1914	July 16, 1915	100	113,235	104,888	5,273		
82	do	7	A	do	do	12.73		Pipe culvert					Jan. 20, 1916	Jan. 31, 1916	100	87	20			
D-97	do	7	A	Station 220				15-foot and 18-foot concrete base	5–6		1-2 –4		May 14, 1920			260,355	8,389	624		
268	do	7	B	Woodland	Zamora	10.71		Surveyed												
	do	7	B			.19		15-foot concrete base	4		1-2 –4		July 12, 1917	Mar. 4, 1920	100	123,010	228,433	8,956		
191	do	7	C	Blacks	Hershey	10.95		15 and 21 foot concrete base	4		1-2 –4			Aug. 19, 1918	100	398	294	40		
D-198	do	7	C	Buckeye Bridge approach		.02		Surveying, total											8,508	293
	do							15-foot concrete base	4–5		1-2½-5		Apr. 16, 1915	Jan. 11, 1916	100	31,632	34,007	3,203		
128	Yuba	3	A	Southerly boundary	Morrison's Crossing	3.33		15 and 21 foot concrete base	4		1-2 –4		Mar. 26, 1919	July 26, 1919	100	780	1,735	452		
D-201	do	3	A	Approaches to Grasshopper Dry Creek and Best Sl. Bridges		.04		Surveyed												
	do	3	A			2.03		15-foot oil macadam	6		[3]		July 23, 1912	Sept. 24, 1913	100	69,345	67,700	4,944		
4	do	3	B	Morrison's Crossing	Marysville	.21		Surveyed											4,883	48
	do	3	B			.19		Surveying, total											1,945	38
	do							Surveyed									1,627			
	do	15	B			12.50		do												
	do	25	A			.93		Grading					Sept. 11, 1917			89,000	93,949		9,950	78
D-154	do	25	A	Southerly boundary	Easterly boundary	11.07										5,724,521	5,876,803	299,076	272,628	5,843
	Total, Division III																			

DIVISION IV.

D-268	Alameda			Equipment house, Oakland maintenance station			Construction					Oct. 15, 1919	Apr. —, 1920	100	$24,200	$28,345	$2,029		
90	do	5	A	Greenville	Livermore	4.97	15-foot concrete base	4		1-2½-5		Aug. 11, 1914	July 20, 1915	100	41,092	49,148	3,231		
108	do	5	A	Easterly boundary	Altamont	6.00	do	4		1-2½-5		Oct. 6, 1914	Aug. 24, 1915	100	66,720	78,173	4,511		
192	do	5	A	Altamont	Greenville	3.68	do	4		1-2 –4		July 12, 1917	Sept. 25, 1918	100	79,512	87,583	4,372		
D-54	do	5	A	Greenville	Easterly boundary	10.84	Oil surfacing				⅜	Aug. 4, 1915	Oct. 19, 1915	100	9,553	8,264	35		
D-338	do	5	A	Altamont	Greenville	.21	15-foot concrete base	4		1-2 –4		May 12, 1920			5,540				
143	do	5	B	Livermore	Santa Rita	5.82	18-foot concrete base	4 –4½		1-2½-5		July 20, 1915	Aug. 24, 1916	100	68,066	63,628	4,445		
179	do	5	B	Santa Rita	Dublin	3.24	do	4½		1-2 –4		May 22, 1917	Jan. 19, 1918	100	53,653	54,521	4,058		
D-314	do	5	B	San Ramon Creek bridge approaches		.11	do	5		1-2 –4		Mar. 11, 1920			3,162	54			
61	do	5	C	Hayward	Valle Vista School	3.12	do	4½		1-2½-5		Apr. 22, 1914	Feb. 9, 1915	100	42,983	40,662	2,613		

[2] Average.

[3] Macadam.

TABLE 2.—*Construction and costs*—Continued.

DIVISION IV—Continued.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
230	Alameda	5	C	Overackers corner	Southerly boundary.	8.40	18-foot concrete base.	4½		1-2 -4	July 19, 1918	Sept. 23, 1919	100	$135,681	$171,562	$7,880			
D-7	do	5	C	Valle Vista School	Niles	6.21	do	4½		1-2½-5	Jan. 19, 1914	Oct. 9, 1915	100	93,111	84,263	2,088			
D-44	do	5	C	Hayward	do	8.96	Oil surfacing		⅜		May 14, 1915	Oct. 11, 1915	100	3,295	7,136	47			
D-119	do	5	C	S. P. R. R. undercrossing.		.90	Concrete base	4½		1-2 -4	Feb. 13, 1917	May 19, 1917	100	1,800	1,133	296			
	do	5	C			.13	Surveyed												
62	do	5	D	Hayward	Oakland	5.06	24-foot Topeka surface.		1½		Apr. 22, 1914	Dec. 22, 1914	100	53,264	65,431	3,211			
	do						Surveying, total										$22,466	$83	
91	Contra Costa	14	A	San Pablo Creek	Pinole	3.59	Grading				Aug. 11, 1914	Feb. 9, 1915	100	19,656	23,843	2,776			
130	do	14	A	Richmond	do	5.37	15 and 18 foot concrete base.	4½		1-2½-5	Apr. 30, 1915	Dec. 7, 1915	100	57,402	48,474	4,358			
170	do	14	A	Southerly boundary	Richmond	2.54	20-foot Topeka on concrete base.	5	1½	1-3 -6	July 10, 1916	Aug. 26, 1917	100	65,837	50,285	4,215			
D-82	do	14	A	300 feet from Alameda County line.			Culverts				Nov. 11, 1915	Dec. 25, 1915	100	1,450	1,654	147			
D-84	do	14	A	Richmond	Pinole	5.37	Oil surfacing		⅜		Nov. 15, 1915	Dec. 11, 1915	100	5,000	4,454	111			
D-86	do	14	A	At San Pablo and Wild Cat Creeks.			Wing wall on bridge.				Dec. 6, 1915	Feb. 16, 1916	100		321	213			
D-332	do	14	A	Intersection, Pt. 14 and Felton Avenue—El Cerito.			Concrete base and top surfacing.	5	1½	1-2 -4	Apr. 23, 1920			1,253					
103	do	14	B	Eckley	Martinez	6.49	Grading				Sept. 22, 1914	July 20, 1915	100	58,953	59,982	7,695			
141	do	14	B	El Ciervo (Tormey)	Eckley	3.46	do				July 7, 1915	Jan. 11, 1916	100	52,054	47,021	3,706			
201	do	14	B	Hercules	do	5.45	15-foot concrete base.	4		1-2 -4	Aug. 28, 1917	Dec. 10, 1918	100	80,201	77,082	5,150			
D-153	do	14	B	Eckley	Martinez	6.99	do	4		1-2 -4	do	Aug. 28, 1919	100	78,704	112,620	4,831			
D-209	do	14	B	At Paloma		.19	Concrete retaining wall.				Sept. 25, 1918	Mar. 31, 1920	100	22,000	13,251	1,094			
D-254	do	14	B	Hercules	Martinez	6.82	Guard rail				Sept. 11, 1919	June 21, 1920	100	39,800	17,215	818			
D-311	do	14	B	Station 355 plus 33	Station 361 plus 58, 98.	.09	Removing slides, concrete base.	4½		1-2 -4	Feb. 28, 1920			30,639					
	do						Surveying, total										22,345	151	
150	Marin	1	A	Northerly boundary	Callinas Creek	4.00	Grading				Aug. 10, 1915	Apr. 25, 1916	100	31,215	25,852	3,802			
208	do	1	A	do	San Rafael	15.97	15-foot concrete base.	4		1-2 -4	Oct. 17, 1917	Dec. 15, 1919	100	274,427	310,833	24,364			
D-85	do	1	A	do	Callinas Creek	1.04	Gravel surfacing				Dec. 2, 1915	Feb. 10, 1916	100	2,800	3,463	43			
D-226	do	1	A	Station 247 plus 35	Station 248 plus 65	.03	Removing slides				Mar. 31, 1919	June 22, 1919	100	6,000	3,695	197			
65	do	1	B	Larkspur	Sausalito	6.00	Grading				May 27, 1914	Dec. 22, 1914	100	72,144	70,571	5,147			
173	do	1	B	do	do	5.06	18-foot concrete base.	4½-5		1-2½-5	July 10, 1916	July 26, 1917	100	60,475	55,788	5,149			
D-36	do	1	B	Ross	Larkspur	.89	do	4½		1-2½-5	Apr. 6, 1915	Dec. 2, 1915	100	16,196	17,634	586			
D-37	do	1	B	At Coyote Creek		.06	Grading				do	July 10, 1915	100	2,645	1,057	305			
D-233	do	1	B	Larkspur	Sausalito	.98	18-foot concrete base.	4½		1-2 -4	May 8, 1919	Sept. 29, 1919	100	28,500	24,749	1,971			
	do	1	B			.80	Surveyed												
	do						Surveying, total										24,340	180	
163	do	8	A	Petaluma Creek bridge.		.27	Bascule bridge				Jan. 11, 1916	June 19, 1917	100	104,828	101,577	6,966			
214	do	8	A	Novato Creek and Simond's Slough.		.14	Concrete bridges				Dec. 19, 1917	June 19, 1918	100	57,140	40,821	705			
234	do	8	A	Ignatio	Black Point	2.75	Grading				Sept. 23, 1918	May 28, 1919	100	14,375	10,926	1,458			
D-110	do	8	A	Station 0	Station 135	2.42	do												
D-282	do	8	A	Petaluma Creek bridge.			Auxiliary power				Aug. 14, 1916	Feb. 19, 1918	100	8,422	14,758	1,236			
D-287	do	8	A	do			Operator's house and lot.				Nov. 16, 1919	Apr. —, 1920	100	500	557	1			
	do						Surveying, total				do			6,900	1,220		7,822	76	
	do	52	A			5.50	Surveyed										1,753		
D-15	Napa	8	A	Westerly boundary	Stanley road	4.25	Oil surfacing, 15-foot concrete base.	4½	⅜	1-2½-5	Sept. 28, 1914	Nov. —, 1915	100	59,206	75,384	3,704			
D-225	do	8	A	Stanley Road	Napa	2.57	15-foot concrete base.	4		1-2 -4	Mar. 27, 1919	Dec. 30, 1919	100	32,227	21,414	2,258			

193	do	8	B	Napa	Easterly boundary	8.63	15-foot and 18-foot concrete base.	4–4½		1–2 –4	July 2, 1917	Feb. 26, 1919	100	149,515	149,162	7,757		
	do						Surveying total										6,558	9
	do																6,662	106
	do	49	A			14.00	Surveyed										219	
	San Francisco	55					do											
1	San Mateo	2	A	South San Francisco	Burlingame	5.41	24-foot asphalt on concrete.	5	1	1–3 –6	July 23, 1912	Aug. 26, 1913	100	100,002	93,034	3,968		
26	do	2	A	Northerly boundary	Southern line, Daly City.	1.02	20-foot Topeka on concrete.	5	1½	1–3 –6	Apr. 23, 1915	Oct. 6, 1915	100	25,067	20,891	2,937		
29	do	2	A	Oak Grove Drive	Bellevue Drive, Burlingame.	.22	do	5	1½	1–3 –6	Apr. 23, 1913	Sept. 22, 1913	100	5,279	5,467	514		
34	do	2	A	Cypress Lawn Cemetery.	South San Francisco.	2.07	Grading				July 3, 1913	Apr. 22, 1914	100	29,110	27,760	2,837		
54	do	2	A	Daly City	Cypress Lawn Cemetery.	4.05	24-foot Topeka on concrete.	5	1½	1–3 –6	Feb. 26, 1914	Dec. 22, 1914	100	105,805	94,289	5,637		
22	do	2	B	Redwood City	Southerly boundary.	3.29	24-foot Topeka on macadam.	5	1½		Mar. 26, 1913	Apr. 25, 1914	100	38,951	50,991	2,637		
27	do	2	B	San Mateo	Beresford	1.76	do	5	1½		Apr. 23, 1913	Jan. 21, 1914	100	23,970	28,230	1,896		
167	do	2	B	Beresford	Redwood City	4.24	20-foot concrete base.	5		1–2 –4	July 10, 1916	Sept. 18, 1917	100	90,576	78,727	4,638		
D-9	do	2	B	San Franquito Creek		.18	20-foot bituminous concrete.	3½	1½			Sept. 21, 1914	100	3,617	6,004	235		
D-26	do	2	B	Redwood City	Southerly boundary.		Retaining wall					Feb. 19, 1916	100		1,082	352		
D-334	do	2	B	Beresford	Redwood City	4.23	20-foot Topeka concrete shoulders.		1½		Apr. 23, 1920			82,942	272			
	do						Surveying total										17,267	8,269
	do	55		S. M., S. Cl., and S. Creeks.		30.00	Surveyed										11,905	91
14	Santa Clara	2	A	Palo Alto	Stevens Creek bridge.	6.43	20-foot Topeka on macadam.		1½		Oct. 22, 1912	Oct. 6, 1914	100	55,343	103,973	5,619		
15	do	2	A	Stevens Creek bridge.	Lawrence Station road.	5.52	20-foot oil surfacing, concrete base.	4	⅜	1–2½–5	do	Sept. 24, 1913	100	52,778	54,352	3,065		
32	do	2	A	Lawrence Station road.	Santa Clara	1.15	20-foot concrete base.	4		1–2½–5	May 21, 1913	Mar. 25, 1914	100	13,704	16,794	1,947		
88	do	2	A	Santa Clara	San Jose	1.93	20-foot Topeka on concrete base.	5	1½	1–3 –6	Aug. 11, 1914	Dec. 7, 1915	100	48,734	45,740	6,143		
D-10	do	2	A	At San Franquito Creek.		.08	20-foot bituminous concrete.	3½	1½			Sept. 21, 1914	100	1,490	2,678	109		
D-157	do	2	A	San Tomes, Aquino Creek.	Santa Clara	.49	20-foot Topeka surfacing concrete base.	4½	1½	1–2½–5	Sept. 15, 1917	Feb. 16, 1918	100	11,147	11,208			
	do	2	A			.93	Surveyed											
23	do	2	B	Edenvale	Morgan Hill	12.95	15-foot concrete base, oil surfacing.	4	⅜	1–2½–5	Mar. 26, 1913	Nov. 10, 1914	100	92,720	111,938	4,484		
28	do	2	B	San Jose	Edenvale	4.35	15 and 20-foot concrete base, oil surfacing.	4	⅜	1–2½–5	Apr. 23, 1913	do	100	36,689	37,085	1,329		
64	do	2	B	do	Mulia	1.84	Topeka surfacing		1½		Apr. 22, 1914	Sept. 22, 1914	100	15,563	15,133	588		
D-21	do	2	B	At Morgan Hill		.40	15-foot concrete base.	4		1–2½–5	Nov. 5, 1914	Sept. 19, 1915	100	4,281	4,774	629		
D-125	do	2	B	Mulia	1 mile north of Coyote.	7.38	Concrete shoulders				Apr. 3, 1917	Jan. 5, 1918	100	36,533	35,336			
D-264	do	2	B	1 mile north of Coyote.	Perry Station	4.17	Concrete shoulders, top surfacing.				Sept. 23, 1919	June 19, 1920	100	54,838	59,693	946		
D-325	do	2	B	Perry Station	Morgan Hill	4.00	do		1½		Apr. 2, 1920			73,761	4,305			
35	do	2	C	Morgan Hill	Gilroy	7.59	15-foot concrete base.	4		1–2½–5	July 3, 1913	Jan. 5, 1915	100	58,730	57,119	4,301		
72	do	2	C	Gilroy	Sargent	6.07	15-foot concrete base, oil surfacing.	4	⅜	1–2½–5	June 9, 1914	July 7, 1915	100	70,128	78,653	3,318		
D-17	do	2	C	Morgan Hill	do	13.59	Oil surfacing		⅜			Mar. 1, 1915	100	9,506	7,803	458		
D-18	do	2	C	At Llagas Creek		.26	15-foot concrete base, oil surfacing.	4	⅜	1–2½–5	Dec. 31, 1913	Dec. 19, 1915	100	4,639	8,590	1,572		
D-158	do	2	C	Approach, Parajo River bridge.		.07	Asphalt concrete	3	2		Sept. 15, 1917	Nov. 24, 1917	100	1,195	1,390			
	do						Surveying total										11,697	134
89	do	5	A	Northerly boundary	San Jose	6.79	18-foot concrete base.	4½		1–2½–5	Aug. 11, 1914	Oct. 5, 1915	100	69,718	68,251	4,722		
D-53	do	5	A	do	do	6.79	Oil surfacing		⅜		Aug. 4, 1915	Nov. —, 1915	100	7,166	5,725	97		
D-156	do	5	A	Milpitas		.42	18-foot concrete base.	4½		1–2 –4	Sept. 15, 1917	May —, 1918	100	6,651	6,598			
102	do	5	B	Southerly boundary	Los Gatos	7.59	Grading				Sept. 22, 1914	Nov. 23, 1915	100	79,725	104,555	10,377		
146	do	5	B	Los Gatos	San Jose	8.89	18-foot concrete base.	4½		1–2½–5	July 23, 1915	July 28, 1916	100	93,786	80,897	4,081		
D-78	do	5	B	do	do	.89	Fencing				Oct. 11, 1915	Dec. —, 1915	100	692	43	4		
D-134	do	5	B	Stevens Creek Road	The Alameda	1.69	Topeka surface		1½		May 25, 1917	Nov. 10, 1917	100	8,946	7,800			
	do						Surveying, total										17,004	257
	do	22	A			.05	Surveyed											
	do	32	A			9.60	do											
	do	32	B			9.40	do											

TABLE 2.—*Construction and costs*—Continued.

DIVISION IV—Continued.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
	Santa Clara	32	C			7.20	Surveyed										$8,996	$299	
	do					26.25	Surveyed, total										7,742	189	See San Mateo for mileage.
	do	55																	
270	Santa Clara and Santa Cruz.	5	A–B	Glenwood	Los Gatos	13.56	15-foot concrete base.	4½		1–2 –4	May 26, 1920			$290,785					
49	Santa Cruz	5	A	Easterly boundary	Glenwood	5.66	Grading				Feb. 26, 1914	July 20, 1915	100	66,704	$85,512	$7,341			
83	do	5	A	Glenwood	Santa Cruz	10.10	do				July 7, 1914	Nov. 9, 1915	100	63,996	86,772	12,622			
218	do	5	A	3 miles south of Glenwood.	do	6.73	15 and 17-foot concrete base.	4		1–2 –4	Mar. 13, 1918	Jan. 9, 1919	100	77,864	84,704	5,034			
243	do	5	A	Glenwood	Sandhill School	3.16	do	4½		1–2 –4	June 5, 1919	Dec. 15, 1919	100	56,858	52,841	4,070			
	do						Surveying, total										20,381	256	
	do	55					Surveying										1,889		
68	Sonoma	1	A	Northerly boundary	Cloverdale	4.29	Grading				May 27, 1914	July 20, 1915	100	45,985	55,753	7,892			
	do	1	A			16.20	Surveyed												
16	do	1	B	Healdsburg	Santa Rosa	13.45	15-foot concrete base, oil surfacing.	4–4½	½	1–2½–5	Oct. 22, 1912	Nov. 10, 1914	100	129,482	198,079	8,740			
D-22	do	1	B	3 miles south of Healdsburg.		.04	Gravel surface				Oct. 20, 1914	Dec. 19, 1914	100	346	116	70			
D-57	do	1	B	Station 130 plus 85.7.	Station 144 plus 78.3.	.25	15-foot concrete base.	4		1–2½–5	Aug. 6, 1915	Mar. 20, 1916	100	5,636	12,982	1,441			
D-88	do	1	B	Healdsburg	Russian River	.58	do	4½			Dec. 17, 1915	Mar. —, 1918	100	9,817	14,957	115			
129	do	1	C	Willow Brook	Southerly boundary.	6.44	do	4½		1–2½–5	Apr. 30, 1915	Dec. 21, 1915	100	80,231	73,791	4,405			
177	do	1	C	Highland Avenue	Willow Brook	3.60	Grading				Oct. 11, 1916	Aug. 26, 1918	100	26,468	21,794	3,261			
206	do	1	C	Santa Rosa	do	12.42	15-foot concrete base.	4–6		1–2 –4	Oct. 17, 1917	Jan. 6, 1920	100	191,940	234,684	10,678			
	do						Surveying, total										36,733	170	
158	do	8	A	Reclamation	Fairville	7.05	Grading				Nov. 25, 1915	Mar. 20, 1917	100	57,606	52,242	4,065			
D-112	do	8	A	Station 52 plus 22	Station 394	6.25	Gravel surfacing				Sept. 9, 1916	June —, 1917	100	6,500	7,017	127			
D-123	do	8	A	Petaluma Creek	Sonoma Creek	11.31	Grading				Apr. 4, 1917	May —, 1917	100	1,787	932				
D-62	do	8	A–B	Sonoma Creek	Easterly boundary	2.32	do				Aug. 24, 1915	May —, 1916	100	10,672	20,115	1,630			
	do	8	B			2.90	Surveyed										12,382	2,172	
D-287	Sonoma and Marin.	8	A	(See D-287, Marin, 8 A.)															
	Sonoma	51	A			15.00	Surveyed										4,369	15	
D-285	do			Petaluma maintenance yard.			Maintenance building				Nov. 13, 1919	May —, 1920	100	12,000	10,338	1,167			
	Totals, Division IV.													4,670,555	4,475,375	291,667	242,530	12,457	

DIVISION V.

41	Monterey	2	A	Lagunita	Easterly boundary	4.34	Grading				Oct. 29, 1913	Nov. 24, 1914	100	$41,798	$35,621	$3,655			
131	do	2	A	Salinas	Lagunita	4.93	15-foot concrete base.	4		1–2½–5	Apr. 30, 1915	Nov. 9, 1915	100	69,792	47,270	1,870			
D-61	do	2	A	Lagunita	Easterly boundary	4.34	do	4		1–2½–5	Sept. —, 1915	Apr. 29, 1916	100	21,352	51,192	3,008			
D-162	do	2	A	Station 210	Station 696	9.20	Oil surfacing		⅜		Sept. 26, 1917			10,540	9,629	51			
137	do	2	B	Chualar	Salinas	10.29	15-foot concrete base.	4		1–2½–5	June 2, 1915	Feb. 23, 1916	100	70,995	82,262	2,964			
D-163	do	2	B	Station 0	Station 545	10.28	Oil surfacing		⅜		Sept. 26, 1917			9,403	9,503	111			
194	do	2	C	Camphora	Chualar	10.95	15-foot concrete base.	4		1–2 –4	July 2, 1917	June 19, 1918	100	111,571	113,501	4,570			
152	do	2	D	Greenfield	Camphora	11.24	do	4		1–2½–5	Aug. 10, 1916	Dec. 19, 1916	100	131,835	107,073	5,552			
D-229	do	2	D	Exception 401 and 430.		.54	do	4		1–2 –4	Apr. 10, 1919			10,419					
133	do	2	E	3.2 miles north of King City.	Greenfield	7.35	do	4		1–2½–5	May 8, 1915	June 7, 1916	100	85,867	73,868	3,256			

D-211	do	2	E	Thompson's Gulch bridge.		.32	Grading				Dec. —, 1918	Feb. —, 1919	100	1,700	1,446	31				
216	do	2	E-F	San Lucas	Layout 25	11.10	15-foot concrete base.	4		1-2 -4	Jan. 9, 1918	Dec. 10, 1918	100	173,279	164,849	4,836				
D-192	do	2	F	King City bridge			Test borings				July —, 1918	Mar. 14, 1919	100	1,000	979					
D-307	do	2	F	Salinas River bridge		.52	Grading approaches.				June 18, 1920	June —, 1920	100	4,200	4,168	30				
244	do	2	F	do		.15	Steel bridge				June 30, 1919			296,177	256,165	3,845				
236	do	2	G	San Ardo	San Lucas	11.11	15-foot concrete base.	4		1-2 -4	Sept. 4, 1918	Feb. 26, 1920	100	171,888	189,789	6,411				
D-188	do	2	G	do	do		Stockpiling materials.				Feb. 19, 1918	Mar. 31, 1919	100	26,500	3,623	282				
132	do	2	H	3 miles north of Bradley.	San Ardo	10.88	15-foot concrete base.	4		1-2½-5	Apr. 30, 1915	Sept. 26, 1916	100	137,470	127,078	6,378				
D-230	do	2	H	do	San Ardo (exceptions).	1.72	do	4		1-2 -4	Apr. 10, 1919	Dec. —, 1919	100	36,300	32,679	2,055				
233	do	2	I	Southerly boundary.	3 miles north of Bradley.	10.24	do	4		1-2 -4	July 19, 1918	Aug. 13, 1919	100	167,542	209,583	5,809				
	do	2	I			.16														
	do						Surveying (total)										$35,369	$382		
	do	10	A			10.00	Surveyed										6,741	355		
	do	56					Surveying										7,226	90		
42	San Benito	2	A	Western boundary	San Juan Bautiste.	4.22	Grading				Oct. 29, 1913	Dec. 8, 1914	100	36,510	47,298	3,263				
D-8	do	2	A	San Juan Bautiste	Northerly boundary.	4.05	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Sept. —, 1914	Apr. —, 1916	100	43,250	67,702	4,014				
D-48	do	2	A	Western boundary	San Juan Bautiste.	5.21	15-foot concrete base.	4		1-2½-5	Dec. 7, 1915	June —, 1916	100		83,224	1,751				
D-89	do	2	A	Through San Juan Bautiste.		.80	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	do	Sept. —, 1916	100	9,695	9,801	138				
D-161	do	2	A	Station 0	Station 248	4.45	Oil surfacing		⅜		Sept. 26, 1917			4,970	3,063	56				
	do						Surveying (total)										10,213	66		
	do	22	A			7.00	Surveyed										238	25		
56	San Luis Obispo.	2	A	Paso Robles	Northerly boundary.	10.63	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Feb. 26, 1914	Aug. 24, 1915	100	111,215	127,129	5,554				
D-136	do	2	A	do	do	.20	15-foot concrete base.	4		1-2 -4	June 19, 1917	Jan. —, 1918	100	2,915	3,147	19				
154	do	2	B	Atascadero Creek	Paso Robles	10.05	do	4		1-2½-5	Aug. 10, 1915	Aug. 24, 1916	100	119,681	117,530	5,302				
D-137	do	2	B	do	do	.71	do	4		1-2 -4	June 19, 1917			8,894	7,911	314				
	do	2	B			2.65	Surveyed													
55	do	2	C	Santa Marguarita	Atascadero Creek	8.35	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Feb. 26, 1914	Feb. 9, 1915	100	85,370	109,406	3,771				
D-138	do	2	C	do	do	.13	15-foot concrete base.	4		1-2 -4	June 19, 1917	June —, 1918	100	1,677	2,162	27				
110	do	2	D	San Luis Obispo Creek.	Ceusta	3.60	Grading				Oct. 24, 1914	Aug. 24, 1915	100	59,135	58,771	4,614				
D-3	do	2	D	San Luis Obispo	Santa Marguarita.	6.37	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	July 23, 1913	Apr. —, 1915	100	62,379	100,930	6,489				
84	do	2	E	Arroyo Grande	San Luis Obispo	13.41	15-foot concrete base.	4		1-2½-5	July 21, 1914	June 22, 1915	100	157,280	182,330	8,310				
D-49	do	2	E	do	do	13.42	Oil surfacing		⅜			May 6, 1919	100	11,811	8,496	527				
D-73	do	2	E	do	do	2.84	Guard rail				Aug. 26, 1915	May —, 1916	100	4,216	4,604	104				
D-139	do	2	E	do	do	.19	15-foot concrete base.	4		1-2 -4	June 19, 1917			2,597	753					
	do	2	E			3.38	Surveyed													
210	do	2	F	Santa Maria River	Arroyo Grande	11.98	15-foot concrete base.	4		1-2 -4	Nov. 19, 1917	Aug. 13, 1919	100	218,453	235,083	9,357				
D-115	do	2	F	do	Nipomo	1.95	Grading				Dec. 15, 1916	Jan. —, 1917	100	5,000	4,922	79				
	do	2	F			2.21	Surveyed													
D-330	do	2	B-E-F	Exceptions		1.42	15-foot concrete base.	4		1-2 -4	Apr. 13, 1920			33,805					L. O. Nos. 125,135,104, 323, 311.	
	do						Surveying (total)										34,741	495		
	do	33	A			11.57	Surveyed													
239	do	33	C	1 mile northeast of Shandon.	Easterly boundary	8.91	Grading				Mar. 7, 1919	Dec. 30, 1919	100	109,690	77,614	3,814				
D-184	do	33	C	At station 145 plus 50		.01	Test borings				Feb. 8, 1918	Aug. —, 1919	100	200	30					
	do						Surveying (total)										8,931	202		
D-310	do			San Luis Obispo			Maintenance building.				Feb. 26, 1920			11,220	601	41			Motor-vehicle fund expenditure.	
	do	56					Surveying										4,389	345		
	do	57	A			11.17	Surveyed										1,805	13		
95	Santa Barbara	2	A	Orcutt	Santa Maria River	6.49	15-foot Topeka on concrete.	4	1½	1-2½-5	Aug. 26, 1914	Aug. 25, 1915	100	98,122	98,806	3,212				
255	do	2	A	do	1 mile south of Divide.	3.56	15-foot concrete base.	4		1-2 -4	Oct. 1, 1919	June 3, 1920	100	85,374	81,603	3,546				
D-72	do	2	A	Santa Maria	Santa Maria River.	.82	Oiled gravel				Dec. 30, 1914	Oct. 23, 1915	100	514	750	22				
D-243	do	2	A	Orcutt	1 mile south of Divide.		Stock piling				Aug. 5, 1919	Mar. —, 1920	100	21,500	4,244					
	do	2	A			2.40	Surveyed													
[illegible]	do	2	B	Los Alamos	Bicknell	11.95	15-foot concrete base, oil surfacing.	4-6	⅜	1-2½-5	July 3, 1913	Jan. 25, 1916	100	128,402	148,936	10,482				
184	do	2	C	Zaca Station	Los Alamos	8.75	15-foot concrete base.	4		1-2 -4	June 6, 1917	Sept. 25, 1918	100	133,236	124,628	7,779				

TABLE 2.—*Construction and costs*—Continued.

DIVISION V.—Continued.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
D-335	Santa Barbara	2	C	Through Los Alamos		0.19	Concrete shoulders				Apr. 22, 1920			$1,850		$3			
D-121	do	2	C-D	Gaviota	Los Alamos		Cattle passes				Mar. 19, 1917	=Aug. —, 1918	100	1,533	$1,454	3			
153	do	2	D	Gaviota Pass	Zaca Station	11.39	Grading				Aug. 10, 1915	Aug. 24, 1916	100	87,813	64,658	5,123			
176	do	2	D	Santa Ynez River bridge.		.68	Steel bridge				Sept. 11, 1916	Mar. 6, 1918	100	165,017	174,992	6,238			
D-118	do	2	D	Zaca Canon bridges		.08	Grading				Feb. 13, 1917	Aug. —, 1917	100	3,600	3,567	22			
D-135	do	2	D	Nojoqui Creek bridge, station 248.		.02	do				June 1, 1917	July —, 1917	100	1,050	1,018	5			L. O. Nos. 192, 292, 271, 248.
D-326	do	2	D-E	Los Cruces	Zaca	15.00	Stock-piling material.				Apr. 2, 1920			109,879	8,507	85			
D-322	do	2	A-C-E	Exceptions		1.22	15-foot concrete base.	4		1-2-4	do			31,373	3,520	14			L. O. Nos, 105, 275, 226.
115	do	2	E	Alcatraz	Los Cruces	4.82	do	4		1-2½-5	Dec. 8, 1914	Apr. 18, 1916	100	93,408	104,012	5,576			134, 137, 322.
182	do	2	E	Los Cruces	Gaviota Pass	2.93	Grading				May 22, 1917	Mar. 13, 1918	100	79,067	65,156	3,438			
D-124	do	2	E	Gaviota Canon bridges.		.14	do				Apr. 4, 1917	Oct. —, 1917	100	2,700	2,620	174			
D-140	do	2	E	Alcatraz	Los Cruces	.46	15-foot concrete base.	4		1-2-4	June 19, 1917	Nov. —, 1917	100	6,120	6,095	70			
92	do	2	F	El Capitan Creek	Alcatraz	9.31	Grading				Aug. 11, 1914	Oct. 5, 1915	100	105,108	97,908	5,747			
197	do	2	F	do	do	9.24	15-foot concrete base.	4		1-2-4	Aug. 9, 1917	Mar. 19, 1919	100	118,255	124,446	4,629			
229	do	2	F	Arroyo Hondo bridge.		.10	Concrete bridge				July 16, 1918	Oct. 15, 1919	100	82,704	87,019	2,790			
D-172	do	2	F	Refugio and Arroyo Hondó bridges.			Borings				Nov. 23, 1917	Dec. —, 1917	100	200	302				
D-207	do	2	F	Canada del Refugio		.02	Concrete bridge				Jan. 13, 1919	May —, 1919	100	13,335	23,148	1,629			
D-213	do	2	F	Canada del Refugio and Arroyo Hondo bridges.			Gravity by-passes				Dec. 28, 1918	Mar. —, 1919	100	15,000	1,266	18			
D-228	do	2	F	At Canada del Refugio bridge.			Grading				Apr. 2, 1919	July —, 1919	100	4,000	3,876	85			
D-248	do	2	F	Refugio and Arroyo Hondo bridges.			15-foot concrete base.	4		1-2-4	Dec. 15, 1919	June —, 1920	100	32,515	23,751	959			
198	do	2	G	Elwood	El Capitan Creek	7.70	do	4		1-2-4	Aug. 9, 1917	Oct. 30, 1918	100	81,071	80,925	4,037			L. O. Nos. 268, 123, 202.
D-141	do	2	G	Station 26 plus 50, near Elwood.		.01	do	4		1-2-4	June 19, 1917	Jan. —, 1918	100	170	150				
109	do	2	G-E	El Capitan Creek	Stony Creek	10.20	Grading and 15-foot concrete base.	4		1-2½-5	Oct. 6, 1914	Nov. 9, 1915	100	123,289	121,896	5,627			
45	do	2	H	Rincon Creek	Carpenteria Creek	2.35	15-foot concrete base.	4		1-2½-5	Nov. 21, 1913	May 27, 1914	100	26,813	30,180	3,101			
D-131	do	2	H	do	do	2.35	Oil surfacing				May 25, 1917	Sept. —, 1917	100	1,213	1,392				
D-132	do	2	I	Stony Creek	Glenn Ann Canon road.	.84	do				do	do	100	432	649				
D-16	do	2	J	County road	Serena Station	.69	15-foot concrete base.	4		1-2½-5	Sept. —, 1914	Aug. 7, 1915	100	9,953	8,152	1,220			
D-133	do	2	J	Near Serena		.69	Oil surfacing				May 25, 1917	Sept. —, 1917	100	355	566				
D-297	do	2	J	East city limits, Santa Barbara.		.10	20-foot concrete base.	4		1-2-4	Jan. 15, 1920	Mar. —, 1920	100	2,500	2,197				
D-295	do	2	J	Ortega Hill		.04	Guard rail				Jan. 14, 1920			200	134				
D-324	do	2	J	Through Summerland.		1.00	15-foot concrete base.	4		1-2-4	Apr. 2, 1920			25,200	1,151	31			
	do	2	K			7.70	Surveyed												
	do						Surveying, total										$54,712	$1,757	
	do	57					Surveyed										2,227	74	
	Totals, Division V.													4,372,462	4,276,459	187,923	166,592	3,804	

48	Fresno	4	A	Fowler	Kingsburg	8.21	15 - foot concrete base, oil surfacing.	4	⅜	1-2½-5	Nov. 21, 1913	Jan. 12, 1915	100	$72,670	$72,034	$4,625			
	do	4	A			1.26	Surveyed												
47	do	4	B	Fowler	Fresno	7.97	20 - foot concrete base, oil surfacing.	4	⅜	1-2½-5	Nov. 21, 1913	Nov. 24, 1914	100	74,351	81,288	3,193			
212	do	4	B	Malaga	do	2.69	Topeka surface		1½		Nov. 19, 1917	Apr. 24, 1918	100	25,519	22,748	3,412			Paid from motor - vehicle funds.
D-312	do	4	B	Intersection Jensen Avenue.	Station 386 plus 76 and station 387 plus 66.	.02	Bituminous pavement.	3½	1½		Mar. 4, 1920			230	230				
D-260	do	4	B-C	Van Ness Boulevard and Belmont Avenue.	Intersection		Concrete base, War. surfacing.	5	1½	1-3 -6	Sept. 8, 1919			1,160	497				Do.
8	do	4	C	Fresno	Herndon	9.56	15 - foot concrete base, oil surfacing.	4	⅜	1-2½-5	Aug. 27, 1912	Jan. 21, 1914	100	65,268	66,633	3,100			Charges incomplete.
	do	4	C			.14	Surveyed												All bills not yet paid.
	do						Surveying, total										$4,848	$231	
	do	10	A			7.60	Surveyed												
	do	10	B			5.60	do												
	do	10	C			10.04	do												
245	do	10	D	Coalinga	Oil King School	8.06	18 - foot concrete base.	6		1-2 -4	July 9, 1919	Mar. 24, 1920	100	246,668	258,371	3,740			
D-337	do	10	D	do	do	8.06	Moving concrete aggregate.				May 6, 1920			250	341				
	do	10	D			.11	Surveyed												
	do	10	E			12.00	do												
	do	10	F			8.10	do												
	do						Surveying, total										14,116	211	
	do	4	A														4	1	
D-291	Inyo	23	A	Independence	Division Creek	2.73	Grading				Oct. 13, 1919	—— —, 1920	100	10,786	16,242	794			
266	do	23	A	Indian allotment	do	7.50	do				Jan. —, 1920			26,604	13,423	1,114			
D-144	do	23	B	Division Creek	Fish Spring School	10.35	8 - foot concrete base, grading.					—— —, 1920	100	107,895	107,103	3,518			
	do	23	C			11.26	Surveyed												
	do	23	D			11.26	do												
	do	23	E			7.85	do												
D-215	do	23	F	Pound Valley	North boundary	5.84	Grading				Jan. 23, 1919	—— —, 1920	100	47,100	41,732	1,954			
	do	23	G			12.50	Surveyed												
	do	23	H			12.10	do												
	do	23	I			10.30	do												
	do	23	J			9.12	do												
	do	23	K			10.00	do												
	do	23	L			10.00	do												
	do	23	N			10.00	do												
	do					104.39	Surveying, total										14,119	366	
	do	63															3		
106	Kern	4	A	South boundary	2.3 miles south of Rose Station.	10.37	Grading				Oct. 6, 1914	Dec. 7, 1915	100	90,361	92,601	9,258			
D-75	do	4	A	do	do	8.66	Oiling graded road				Sept. 24, 1915	Feb. 26, 1916	100		3,617	289			
D-249	do	4	A	do	do	10.74	20 - foot concrete base.	5		1-2 -4	Aug. 20, 1919			409,528	157,394	1,387			
96	do	4	B	Grapevine Creek	Secs. 5 and 6, T. 32 S., R. 28 E.	17.29	15 - foot concrete base.	4-6		1-2½-5	Aug. 26, 1914	May 12, 1916	100	233,782	283,630	9,734			
D-96	do	4	B	do	do	17.29	Oiling surface		⅜		Jan. 7, 1916	Nov. —, 1916	100	15,215	8,018				
D-333	do	4	B	Station 780 plus 17	Station 832 plus 97	1.00	15 - foot concrete base.	4		1-2 -4	Apr. 22, 1920			20,340	4,043				
D-336	do	4	B	Grapevine Canyon	Sec. 17, T. 32 S., 28 E.	15.00	Oil surfacing		⅜		Apr. 28, 1920			21,340	2				
67	do	4	C	Secs. 5 and 6, T. 32 S., R. 28 E.	Bakersfield	12.98	15 - foot concrete base.	4		1-2½-5	May 27, 1914	Aug. 10, 1915	100	133,466	141,531	6,998			
D-51	do	4	C	do	do	12.98	Oil surfacing		⅜			Aug. 17, 1915	100	11,423	8,323	276			
50	do	4	D	Bakersfield	Lerdo	10.12	15 to 24 foot concrete base.	4-6		1-2½-5	Feb. 26, 1914	Dec. 22, 1914	100	82,628	76,820	4,575			
D-30	do	4	D	Beardsley Canal		.01	Reinforced concrete bridge.				Jan. 12, 1915	Apr. 24, 1915	100	5,100	5,558	418			
D-32	do	4	D	Bakersfield	Lerdo	10.14	Oil surface		⅜			Oct. —, 1915	100	8,923	6,646	260			
51	do	4	E	Lerdo	Famoso	9.06	15 - foot concrete base.	4		1-2½-5	Feb. 26, 1914	Apr. 30, 1915	100	67,853	63,598	4,059			
D-41	do	4	E	do	do	9.09	Oil surfacing		⅜			Oct. —, 1915	100	7,867	5,257	217			
63	do	4	F	North boundary	Dearborn	12.45	15 - foot concrete base.	4		1-2½-5	Apr. 22, 1914	Jan. 12, 1915	100	97,093	102,109	3,702			
D-35	do	4	F	do	do	12.44	Oiled surfacing		⅜			Oct. —, 1915	100	10,940	7,165	313			
	do						Surveying, total										16,412	292	
	do	23	A			16.36	Surveyed												
	do	23	B			16.75	do												
	do	23	C			9.38	do												
	do	23	D			9.07	do												

TABLE 2.—*Construction and costs*—Continued.

DIVISION VI.—Continued.

Contract No.	County.	Route, No.	Route, Sec.	Location, From—	Location, To—	Length (miles).	Type of work.	Thickness (inches), Base.	Thickness (inches), Surface.	Mixture proportions of base.	Date of—, Contract.	Date of—, Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments, Labor and materials.	Direct construction payments, Field engineering during construction.	Payments for—, Preliminary surveys.	Payments for—, Legal and general.	Remarks.
	Kern	23	E			7.97	Surveyed												
	do	23	F			5.76	do												
	do	23	G			9.23	do												
	do	33	A			14.25	do												
	do	33	B			17.50	do												
	do	33	C			19.00	do												
	do	33	D			7.50	do												
	do					132.77	Surveying, total										$2,583	$102	
	do	57	J			9.90	Surveyed												
	do	57	K			11.40	do												
	do	57	L			8.90	do												
						30.20	Surveying, total										6,130	12	
138	Kings	10	A	Hanford	East boundary	8.96	15-foot concrete base.	4		1-2½-5	June 22, 1915	Apr. 18, 1916	100	$86,471	$95,031	$3,515			
D-276	do	10	A	Station 20 plus 50			Concrete culverts				Oct. 23, 1919	Nov. —, 1919	100	635	488				
	do	10	B			12.40	Surveyed										5,094	33	
9	Madera	4	A	South boundary	Madera	9.99	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Aug. 27, 1912	June 21, 1914	100	68,404	73,665	4,234			
	do	4	A			.06	Surveyed												
3	do	4	B	Madera	Califa	10.00	15-foot oil macadam.	6			July 23, 1912	Oct. 29, 1913	100	68,213	68,927	4,905			
10	do	4	C	Califa	North boundary	6.98	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Aug. 27, 1912	Nov. 24, 1914	100	47,247	49,836	4,663			
	do	4	C			0.2	Surveyed												
	do						Surveying, total										4,222	28	
	do	32	A			15.70	Surveyed										1,322	38	
157	Mariposa	18	A	West boundary	Cathay Wh. Park Road.	10.05	Grading				Nov. 9, 1915	Feb. 20, 1917	100	53,596	72,342	5,880			
D-111	do	18	A	Owens Creek bridge.	Station 409	.02	Concrete bridge				Oct. 11, 1916	Mar. 13, 1917	100		5,400	443			
D-143	do	18	A	West boundary	Station 531	10.06	Oil surfacing		⅜		July 3, 1917	Oct. 6, 1917	100	3,382	1,875	28			
D-108	do	18	B	Cathay Wh. Park Road.	Agua Fria Creek	7.83	Grading				July 28, 1916	Feb. 15, 1918	100	51,195	141,806	5,065			
D-170	do	18	C	Agua Fria Creek	Mariposa	6.70	do				Oct. 17, 1917	July 6, 1918	100	61,062	89,852	1,898			
D-244	do	18	C	do	Bridge	.03	Concrete bridge				Aug. 5, 1919	Dec. 5, 1919	100	9,450	9,441	75			
	do	18	D			7.80	Surveyed												
	do	18	E			9.60	do												
	do	18	F			6.80	do												
	do	18	G			6.00	do												
D-294	do	18	H	El Portal	Yosemite Valley Park boundary.	1.28	Grading				Jan. 6, 1920			39,651	34,155	602			
	do						Surveying, total										41,848	178	
69	Merced	4	A	Merced	South boundary	14.27	15-foot concrete base.	4		1-2 -4	May 27, 1914	Aug. 10, 1915	100	102,033	121,159	6,945			
D-42	do	4	A	do	do	14.35	Oil surfacing		⅜			Jan. —, 1916	100	12,470	9,131	393			
D-176	do	4	A	Station 261 plus 13		.01	15-foot concrete base.	4		1-2 -4	Dec. 31, 1917	Nov. 23, 1916	100	200	190				
D-182	do	4	A	Station 483 plus 15	Station 483 plus 47	.01	do	4		1-2 -4	Jan. 24, 1918	July —, 1919	100	354	319				
D-221	do	4	A	Station 312 plus 13.5	Station 312 plus 92		do	4		1-2 -4	Mar. 14, 1919	Aug. 2, 1919	100	290	209				
	do	4	A			.08	Surveyed												
11	do	4	C	Arena	Merced	10.86	15-foot concrete base, oil surfacing.	4-5	⅜	1-2½-5	Sept. 25, 1912	Nov. 24, 1914	100	88,144	96,016	6,926			
D-177	do	4	C	Station 884 plus 33		.01	15-foot concrete base.	4		1-2 -4	Dec. 31, 1917	Jan. 11, 1919	100	294	1,055	341			
D-289	do	4	C	Atwater			7¼-foot concrete shoulders.				Nov. 6, 1919	June 9, 1920	100	1,620	1,551				
6	do	4	D	North boundary	Arena	9.74	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Aug. 27, 1912	Feb. 26, 1914	100	67,251	75,484	4,244			
D-145	do	4	D	Station 6 plus 58 and station 7 plus 41.		.02	15-foot concrete base.	4		1-2 -4	July 5, 1917	Aug. 31, 1918	100	1,650	688				

D-185	.....do.....	4	D	Station 7 plus 15 and station 104 plus 00 and station 247 plus 00.		.02	Bridges.....				Feb. 14, 1918	Apr. —, 1918	100	1,521	3,595	45		
D-246	.....do.....	4	D	Station 375 plus 00–station 497 plus 00.			Culverts.....				Aug. 5, 1919	Nov. 22, 1919	100	1,750	3,282			
D-331	.....do.....	4	D	Livingston.....		.15	Concrete shoulders				Apr. 13, 1920	—— —, 1920	100	1,275				
D-339	.....do.....	4	D	Delhi.....	Stanislaus County line.	9.62	.....do.....							28,405				
	.....do.....	4	D			.26	Surveyed.....											
	.....do.....						Surveying, total...										5,509	99
246	.....do.....	18	A	Merced.....	East boundary....	14.89	18-foot concrete base.	4	.....	1-2 -4	July 3, 1919			272,194	105,506	5,313		
	.....do.....						Surveying, total...										1,805	131
	.....do.....	32	A			8.60	Surveyed.....											
	.....do.....	32	B			13.25	.....do.....											
	.....do.....	32	C			19.80	.....do.....											
	.....do.....					41.65	Surveying, total...										6,222	224
D-79	Mono.....	23	A	South boundary.....	Sherwin Hill.....	5.80	Grading.....				Oct. 4, 1915	Dec. 22, 1917	100	27,968	45,171	3,319		
D-101	.....do.....	23	B	Sherwin Hill.....	Whiskey Canyon..	4.80	.....do.....				Apr. 4, 1916	Feb. —, 1917	100	8,000	18,664	346		
K-128	.....do.....	23	B	Rock Creek bridge..			Concrete bridges..				May 15, 1917	Feb. 28, 1918	100	3,477	8,242	189		
D-191	.....do.....	23	B	Rock Creek Canyon.		3.28	Grading.....				Apr. 30, 1918	Oct. 10, 1918	100	5,000	7,668	187		
D-129	.....do.....	23	C	Hilton and McGee Creeks.			Bridges.....				Mar. 15, 1917	July 26, 1919	100	2,318	7,158	304		
D-218	.....do.....	23	C	Whiskey Creek Canyon.	McGee Creek.....	7.61	Grading.....				Mar. 6, 1919			91,100	64,337	3.020		
D-130	.....do.....	23	D	Convict and Hot Creeks.			Bridges.....				May 15, 1917	Dec. —, 1918	100	4,498	11,039	748		
	.....do.....	23	D			8.61	Surveyed.....											
D-197	.....do.....	23	E	Station 0 plus 00....	Station 10 plus 00 .	.19	Grading.....				July 13, 1918	Dec. —, 1918	100	943	1,734	274		
	.....do.....	23	E			8.70	Surveyed.....											
D-103	.....do.....	23	F	Deadman Creek.....	Devils Punch Bowl.	5.80	Grading.....				Apr. 24, 1916	Sept. —, 1918	100	31,662	27,843	1,159		
D-194	.....do.....	23	G	Devils Punch Bowl.	Tioga Road, route 40.	11.70	.....do.....				June 19, 1918			62,397	39,118	1,877		
	.....do.....	23	H			13.41	Surveyed.....											
	.....do.....	23	I			12.88	.....do.....											
	.....do.....						Surveying, total...										18,382	300
	.....do.....	40	B			3.70	Surveyed.....											
185	Tulare.....	4	A	Earlimart.....	Pixley.....	5.87	15-foot concrete base.	4	.....	1-2 -4	June 6, 1917	Mar. 6, 1918	100	57,879	63,698	1,573		
190	.....do.....	4	A	South boundary.....	Earlimart.....	6.63	.....do.....	4	.....	1-2 -4	.....do.....	.....do.....	100	61,900	72,076	2,246		
195	.....do.....	4	A-B	Pixley.....	Tipton.....	6.36	.....do.....	4	.....	1-2 -4	July 2, 1917	.....do.....	100	65,440	71,194	2,357		
196	.....do.....	4	B	Tipton.....	Tulare.....	9.18	.....do.....	4	.....	1-2 -4	.....do.....	Feb. 26, 1919	100	108,587	122,827	6,888		
189	.....do.....	4	C	½ mile west of Visalia	.....do.....	9.16	.....do.....	4	.....	1-2 -4	June 6, 1917	Dec. 10, 1918	100	93,197	102,336	5,829		
149	.....do.....	4–10	D-B	Goshen.....	Visalia.....	6.42	.....do.....	4	.....	1-2½-5	Aug. 10, 1915	July 28, 1916	100	61,339	61,938	4,094		
D-265	.....do.....	10–4	B-D	Visalia.....	Fulgam's Corner..	1.47	Topeka surfacing-concrete shoulders.	.....	1½	.....	Oct. 15, 1919			22,221	22,046	21		
125	.....do.....	4	E	Traver.....	North boundary...	5.20	15-foot concrete base.	4	.....	1-2½-5	Apr. 16, 1915	Nov. 9, 1916	100	52,685	47,312	2,321		
126	.....do.....	4	E	Goshen.....	Traver.....	8.47	.....do.....	4	.....	1-2½-5	.....do.....	Feb. 11, 1916	100	77,556	69,545	3,514		
D-94	.....do.....	4	E	Traver.....	North boundary...	5.35	Oil surfacing.....	.....	⅜	.....	Jan. 7, 1916	Feb. 12, 1916	100	4,703	1,391	73		
D-142	.....do.....	4	E	Kings River bridge.		.25	15-foot concrete base.	4	.....	1-2 -4	June 26, 1917	Sept. —, 1917	100	1,658	1,640	5		
D-95	.....do.....	4	E	Goshen.....	Traver.....	8.39	Oil surfacing.....	.....	⅜	.....	Jan. 7, 1916			7,384	10			
	.....do.....						Surveying, total...										11,923	229
148	.....do.....	10	A	West boundary.....	Near Goshen.....	3.94	15-foot concrete base.	4	.....	1-2½-5	Aug. 10, 1915	May 12, 1916	100	32,072	29,443	2,158		
D-308	.....do.....	10	A	.....do.....	S. P. R. R.....	4.00	Oiled surface.....	.....	⅜	.....	Feb. 26, 1920			6,740	1,065			
	.....do.....	10	F			5.90	Surveyed.....										7,077	109
	Totals, Division VI.													3,853,791	3,605,452	164,953	161,619	2,584

DIVISION VII.

107	Imperial.....	12	A	Myers Creek.....	Coyote Wells.....	6.02	15-foot concrete base.	4	.....	1-2½-5	Oct. 6, 1914	June 7, 1916	100	$100,061	$105,953	$6,665		
159	.....do.....	12	A	Myers Creek bridge.		.06	Concrete bridge...				Nov. 23, 1915	Feb. 20, 1917	100	29,296	33,570	2,529		
D-100	.....do.....	12	A	San Diego & Arizona R. R. crossing.			Abutments for subway.					July 22, 1916	100	10,000	12,614	35		
D-107	.....do.....	12	A	Myers Creek.....	Coyote Wells.....		Constructing detours.					.....do.....	100	500	2,070	32		
D-296	.....do.....	12	A	Myers Creek road...		5.11	Grading.....				Jan. 14, 1920			20,000	14,458	109		
	.....do.....	12	A			.51	Surveyed.....											
116	.....do.....	12	B	Coyote Wells.....	Dixie Land.....	11.74	15-foot concrete base.	4	.....	1-2½-5	Dec. 8, 1914	Feb. 11, 1916	100	120,855	111,536	5,481		
161	.....do.....	12	C	Dixie Land.....	El Centro.....	11.87	.....do.....	4	.....	1-2½-5	Dec. 12, 1915	Feb. 20, 1917	100	133,853	105,005	4,711		
178	.....do.....	12	C	New River bridge...		.06	Concrete bridge...				Feb. 6, 1917	Mar. 13, 1918	100	23,535	19,538	1,621		
D-165	.....do.....	12	C	Paving at Brawley Canal.		.01	15-foot concrete base.	4	.....	1-2 -4	Oct. 6, 1917	—— —, 1920	100	150				

TABLE 2.—*Construction and costs*—Continued.

DIVISION VII.—Continued.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
D-183	Imperial	12	C	New River bridge			Grading				Jan. 31, 1918	Mar. 13, 1918	100	$3,105	$2,663	$79			
D-223	do	12	C	Approach to New River bridge.			15-foot concrete base.	4		1-2 -4	Mar. 26, 1919	Aug. 9, 1919	100	5,540	6,856	82			
D-288	Imperial, San Diego.	12	H	Westerly boundary.	Mountain Springs grade.	.98	do	4		1-2 -4	Nov. 6, 1919			34,099	31,047	224			
	do						Surveying, total										$22,550	$82	
	Imperial	26	A-G																
			F-H			26.31	Surveyed												
	do	26	B			6.99	do												
D-214	do	26	C	Kane Springs	Tule Wash	11.33	8 and 15 foot concrete base.	4		1-2 -4	Jan. 2, 1919	June 12, 1920	100	295,006	316,885	4,818			
	do	26	D			6.59	Surveyed												
D-304	do	26	E	Gravel Wash	Northerly boundary.	8.33	15-foot concrete base.	4		1-2 -4	Feb. 4, 1920			186,070	73,582	225			
	do						Surveying, total										7,472	98	
D-292	do	27	A	High-line canal	1 mile east	1.00	15-foot Willite	3-5			Dec. 15, 1919	May 19, 1920	100	41,635	43,455	911			
	do	27	A			20.50	Surveyed												
	do	27	B			12.70	do												
	do	27	C			8.83	do												
	do	27	D			6.94	do												
	do					48.97	Surveyed, total										5,671	63	
17	Los Angeles	2	A	County highway No. 3.	Rancho El Encino.	6.55	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Oct. 22, 1912	Jan. 9, 1914	100	59,119	51,177	3,494			
251	do	2	A	Lankershim Boulevard.	South Sherman Way.	5.22	20-foot concrete base, 1½-inch asphalt surfacing.	4	1½	1-2 -4	Oct. 3, 1919	Feb. 4, 1920	100	90,974	60,565	1.728			
21	do	2	B	Rancho El Encino	Calabasas	10.27	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Mar. 4, 1913	Oct. 20, 1914	100	83,516	98,360	7,727			
33	do	2	C	Calabasas	Westerly boundary.	11.28	15-foot concrete base.	4		1-2½-5	May 21, 1913	Jan. 5, 1915	100	124,948	137,813	8,609			
D-14	do	2	C	do	do	11.28	Oil surfacing		⅜			June 27, 1915	100	6,963	19,524	638			
D-278	do	2	C	Calabasas maintenance station.			Warehouse and fence.				Oct. 23, 1919	Mar. 6, 1920	100	2,500	2,980				
257	do	2	C	Russells ranch	Former east boundary.	1.29	18-foot concrete base.	4		1-2 -4	Oct. 10, 1919			45,347	34,734	896			
	do	2	D			14.13	Surveyed										13,460	433	
134	do	4	A	Saugus	Castaic	4.21	15-foot concrete base	4		1-2½-5	June 1, 1915	Mar. 7, 1916	100	21,101	31,498	3,225			
181	do	4	A	Castaic	Castaic School	4.08	do	4		1-2 -4	May 22, 1917	Apr. 24, 1918	100	47,360	40,907	3,125			
D-91	do	4	A	Santa Clara			Bank protection					Feb. 19, 1916	100		3,133	242			
D-199	do	4	A	Newhall property			Fencing right of way.				Aug. 19, 1918	Oct. 19, 1918	100	550	491				
D-329	do	4	A-B	Station 320 (Sec. A)	Station 200(Sec. B)	4.22	Willite and Topeka surface.		1-1½		Apr. 2, 1920	June —, 1920	100	41,741	10,209	366			All bills not yet paid.
161	do	4	B	Castaic	Sec. 17, T. 6 N., R. 17 W.	12.84	Grading				Sept. 22, 1914	Oct. 5, 1915	100	199,114	134,815	12,735			
202	do	4	B	do	Kay ranch	3.79	20-foot concrete base.	4		1-2 -4	Aug. 28, 1917	June 19, 1918	100	56,260	71,122	4,617			
D-63	do	4	B	do	Sec. 17, T. 6 N., R. 17 W.	12.84	Oiling graded road				Aug. 24, 1915	July 15, 1916	100	54,842	59,598	1,894			Cost under D-63 includes cost incurred on D-64.
D-217	do	4	B-C	Completing ridge route.		14.92	20-foot concrete base (see *a*).	4		1-2 -4	Sept. 11, 1919	Dec. 12, 1919	100	373,754	357,286	5,609			
D-127	do	4	B-C-D	Castaic	Northerly boundary.		Grading and widening curves (see *b*)				May 14, 1917	Mar. 19, 1918	100	51,360	34,040	205			(*a*) Secs. B and C.
120	do	4	C	Sec. 17, T. 6 N., R. 17 W.	Liebre Mountain	14.52	Grading				Dec. 22, 1914	Oct. 5, 1915	100	416,454	315,804	13,871			(*b*) L. O. Nos. 98, 99, 151, Secs. B. C. D.
D-64	do	4	C	do	do	14.52	Oiling graded road				Aug. 24, 1915	Dec. —, 1915	100	See D-63		See D-63			
D-146	do	4	C	Pipeline to ridge route.			Move pipe line				July 6, 1917	Dec. 8, 1917	100	4,020	3,754				

74	do	4	C	Opening quarries on ridge route.			Rock supplies				Nov. 25, 1917	Dec. 15, 1917	100		1,309					
D-178	do	4	C-D	Station 567 (Sec. C).	Station 128 (Sec. D)	6.76	20-foot concrete base.	4		1-2 -4	Jan. 10, 1918	Nov. —, 1918	100	154,744	195,696	2,525			Secs. C and D.	
78	do	4	D	Liebre Mountain	Northerly boundary.	12.62	15-foot concrete base.	4		1-2½-5	June 9, 1914	Nov. 23, 1915	100	235,569	180,218	14,643				
D-90	do	4	D	do	do	8.34	Oil surfacing					Jan. —, 1916	100	7,341	5,665	358				
D-168	do	4	D	do	do	4.28	do					Oct. 11, 1917	Dec. 8, 1917	100	3,764	3,366	212			
	do	4	E			6.43	Surveyed											46,798	380	
	do						Surveying, total													
147	do	9	A	Rancho Tujunga	La Canada	4.90	15-foot concrete base	4		1-2½-5	July 23, 1915	Mar. 25, 1916	100	53,203	51,997	4,756				
213	do	9	A	San Fernando	Rancho Tujunga	10.02	do	4		1-2 -4	Nov. 19, 1917	Jan. 23, 1919	100	122,839	138,791	7,981				
D-234	do	9	A	At dangerous points		.30	Guard rail				May 23, 1919	Dec. —, 1919	100	1,000	718					
	do	9	A			.28	Surveyed													
	do	9	C			.18	do													
D-39	do	9	C-D	County highway division 34.	Easterly boundary	.60	18-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Apr. 6, 1915	Oct. —, 1915	100	10,410	10,028	850				
	do	9	D			.42	Surveyed													
	do	9	E			5.33	do													
	do	9	G			4.15	do													
	do	9	H			1.67	do													
D-190	do	9	I	Near Glendora			Bank protection					Mar. 13, 1918	100	400	400					
	do	9	I			5.44	Surveyed													
	do	9	J			2.21	do											11,611	94	
	do						Surveying, total											84		
	do	19	A			.60	Surveyed													
	do	23	A			4.80	do													
237	do	23	B	Santa Clara River bridge.		.04	Concrete bridge				Feb. 3, 1919	Aug. 13, 1919	100	12,311	11,667	808				
250	do	23	B	Santa Clara River	Williams ranch	1.86	20-foot concrete base	4		1-2 -4	Sept. 3, 1919	Feb. 26, 1920	100	63,947	49,631	1,456				
D-167	do	23	B	Santa Clara River bridge.			Concrete piling					Aug. 16, 1919	100	1,621	1,621					
D-306	do	23	B	Santa Clara River bridge approaches			Grading				Feb. 14, 1920	Feb. —, 1920	100	300	104					
	do	23	C			8.42	Surveyed													
	do	23	C								July 18, 1917	Aug. —, 1918	100	156,602	207,345	5,514				
D-150	do	23	D	Seeley ranch	Acton	10.60	20-foot concrete base	4		1-2 -4	Jan. 16, 1918	Apr. 27, 1918	100		18,512	662				
D-179	do	23	E	Near Acton	Palmdale	8.64	Grading							293,778	82,475	3,630				
258	do	23	E	2 miles north of Acton	do	8.64	20-foot concrete base	4		1-2 -4	Oct. —, 1919									
	do	23	E			3.18	Surveyed													
D-267	do			Lankershim maintenance station.			Equipment house				Oct. 15, 1919	June —, 1920	100	16,200	14,524	109			Paid from Motor-vehicle funds.	
	do	23	G			8.14	Surveyed											7,189	112	
	do						Surveying, total											16		
	do	59					Surveyed													
	do	60	A			19.14	do													
	do	60	B			7.42	do													
	do	60	C			18.82	do													
	do	60	D			20.47	do													
	do	60	E			10.48	do											5,950	2	
	do					76.33	Surveying, total											3,072	7	
	do	61					Surveyed											12		
	do	62					do													
119	Orange	2	A	San Juan Capistrano	Galivan	5.57	15-foot concrete base	4		1-2½-5	Dec. 22, 1914	Sept. 16, 1915	100	47,830	51,531	2,613				
123	do	2	A	Sec. 32, T. 8 S., R. 7	Serra	3.80	Grading				Apr. 6, 1915	Dec. 21, 1915	100	39,515	37,939	3,440				
D-19	do	2	A	Easterly boundary	Sec. 32, T. 8 S., R. 7 W	3.56	15-foot concrete base	4		1-2½-5	Oct. 24, 1914	Mar. 25, 1915	100		38,205	1,618				
D-25	do	2	A	Serra	San Juan Creek	2.19	do	4		1-2½-5	Jan. 8, 1915	Oct. —, 1915	100		25,613	1,729				
D-45	do	2	A	Galivan	Southerly boundary.	15.08	Detours				June 2, 1915	Dec. —, 1915	100		2,466	220			L. O. Nos. 149, 163, 143, 156.	
D-66	do	2	A	Sec. 32, T. 8 S., R. 7 W	Serra	3.07	15-foot concrete base	4		1-2½-5	Aug. 24, 1915	Nov. —, 1915	100		22,027	468				
D-76	do	2	A	Southerly boundary.	San Juan Creek	8.82	Oil surfacing		⅜			Mar. —, 1916	100		13,740	505			L. O. Nos. 143, 155, 163.	
D-160	do	2	A	Near Serra		.40	15-foot concrete base	4		1-2 -4	Sept. 24, 1915	Oct. —, 1915	100	2,500	2,469	113				
	do	2	A			.32	Surveyed													
97	do	2	B	Galivan	Irvine	9.37	15-foot concrete base	4		1-2½-5	Aug. 26, 1914	Nov. 9, 1915	100	96,836	96,006	5,128				
252	do	2	B	do	do	9.37	Topeka surfacing concrete shoulders.		1½		Sept. 20, 1917	Feb. 26, 1920	100	127,172	106,055	2,187				
D-77	do	2	B	do	do	9.37	Oil surfacing		⅜			Jan. —, 1916	100	8,242	4,538	683			Superseded by M. R. 741-764.	
D-164	do	2	B	Aliso Creek bridge		.01	Concrete pile trestle.				Oct. 14, 1917	Oct. 25, 1918	100	4,454	488					
98	do	2	C	Irvine	Santa Ana	7.40	15 and 18 foot concrete base.	4		1-2½-5	Sept. 10, 1914	Aug. 10, 1915	100	65,305	54,841	3,651				
D-59	do	2	C	do	do	7.40	Oil surfacing		⅜			Dec. —, 1915	100	6,795	5,904	833				
D-12	do	2	D	Santa Ana	Anaheim	4.94	Topeka surface		1½		Aug. 13, 1914	Oct. 13, 1914	100	(1)	16,816	364				
D-224	do	2	D	do	Station 3 plus 00	.06	18-foot concrete base	4		1-2-4	Mar. 26, 1919	Nov. 19, 1919	100	1,400	1,350	24				
40	do	2	DEF	do	Northerly boundary.	11.16	do	4		1-2½-5	Oct. 29, 1913	Dec. 8, 1914	100	96,971	94,624	5,672				

(1) Unit base.

TABLE 2.—*Construction and costs*—Continued.

DIVISION VII—Continued.

Contract No.	County.	Route. No.	Route. Sec.	Location. From—	Location. To—	Length (miles).	Type of work.	Thickness (inches). Base.	Thickness (inches). Surface.	Mixture proportions of base.	Date of— Contract.	Date of— Completion.	Per cent complete.	Preliminary estimate of cost labor, and materials.	Direct construction payments. Labor and materials.	Direct construction payments. Field engineering during construction.	Payments for— Preliminary surveys.	Payments for— Legal and general.	Remarks.
D-20	Orange	2	E	Anaheim	Fullerton	1.51	Topeka surfacing		1½		Oct. 20, 1914	Nov. 2, 1914	100	(5)	$6,483	$359			
D-23	do	2	F	Fullerton	Northerly boundary.	4.75	Oil surfacing		⅜			Mar. 20, 1915	100	$5,572	5,637	883			
	do						Surveying, total										$14,082	$183	
	do	60	A			17.26	Surveyed												
	do	60	B			7.64	do												
	do	60	C			8.44													
	do					33.34	Surveying, total										2,702		
	Riverside	9					Surveyed										892	1	
43	do	19	A	Westerly boundary.	Riverside	9.32	18-foot concrete base.	4		1-2½-5	Oct. 29, 1913	Dec. 22, 1914	100	74,223	71,612	4,886			
D-31	do	19	A	do	do	9.32	Oil surfacing		⅜		Mar. 16, 1915	Sept. —, 1915	100	10,956	7,346	877			
	do	19	A	do	do	1.02	Surveyed										1,036	54	
	do	26	A			6.81	do												
	do	26	A-B	County highway No. 32.	Beaumont	7.10	Grading				Dec. 31, 1919			100,298	46,023	2,643			
	Riverside and San Bernardino.	26	CDE			41.98	Surveyed												
D-227	Riverside	26	E	City of Indio		.71	15-foot concrete base.	4		1-2 -4	Apr. 2, 1919	Aug. —, 1919	100	14,000	14,315	436			
D-210	do	26	F	Northwest sec. 20, T. 6 S., R. 8 E.	Northeast corner sec. 6, T. 7 S., R. 8 E.	3.01	do	4		1-2 -4	Nov. 25, 1918	May —, 1919	100		58,985	927			
	do	26	F			5.55	Surveyed												
267	do	26	G	Northeast corner of sec. 6.	Southerly boundary.	14.33	15-foot concrete base.	4		1-2 -4	Apr. 2, 1920			320,692	66,906	1,734			
	do						Surveying, total										11,459	105	
	do	64					Surveyed										32		
46	San Bernardino.	9	A	Upland	Citrus Avenue	10.36	18-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Nov. 21, 1911	Mar. 23, 1915	100	94,078	90,130	6,148			
38	do	9	B-C	Citrus Avenue	San Bernardino	5.83	do	4	⅜	1-2½-5	Aug. 11, 1913	Aug. 11, 1914	100	49,254	51,501	4,907			
D-159	do	9	C	Lytle Creek bridge extension.		.07	Bridge				Sept. 19, 1917	Dec. 7, 1917	100	4,268	3,179	250			
53	do	9	D	Westerly boundary	Upland	1.68	18-foot concrete base.	4		1-2½-5	Feb. 26, 1914	Nov. 24, 1914	100	19,573	22,655	2,365			
D-46	do	9	D	do	do	1.69	Oil surfacing		⅜			Oct. —, 1915	100	1,982	983	23			
D-186	do	9	D	Through Upland		.54	18-foot concrete base.	4		1-2 -4		May 17, 1918	100	5,794	5,415	36			
	do						Surveying, total										4,364	113	
37	do	19	A-B	Westerly boundary	Southerly boundary.	6.61	18-foot concrete base, oil surfacing.		⅜	1-2½-5	July 23, 1913	June 23, 1914	100	57,873	58,348	4,293			
D-24	do	19	B	Ontario	do	.13	do		⅜	1-2½-5		Sept. —, 1915	100	(5)	1,693	15			
	do						Surveying, total										2,344	35	
	do	26	B			5.12	Surveyed												
262	San Bernardino and Riverside.	26	A-B	(See No. 262, Riverside, 26 A and B.															
	do						Surveying, total										347		
	Riverside	31	C			15.73	Surveyed												
	do	31	D			15.70	do												
	do	31	E			9.60	do												
	do	31	F			11.20	do												
	do					52.23	Surveying, total										8,234	5	
	do	43					Surveyed										30		
7	San Diego	2	A	San Diego	Encinitas	8.42	15-foot concrete base, oil surfacing.	4	⅜	1-2½-5	Aug. 27, 1912	Sept. 22, 1913	100	58,389	69,638	3,929			
D-298	do	2	A	At San Diego River and Escondito Creek bridges.		.17	15-foot concrete base.	6		1-2 -4	Jan. 22, 1920	Apr. 5, 1920	100	1,671	1,192	73			
30	do	2	B	Encinitas	Oceanside	10.63	do	4		1-2½-5	May 21, 1913	July 21, 1914	100	79,302	84,248	4,017			
221	do	2	B	Through city of Oceanside.		1.91	15 and 20 foot concrete base.	4		1-2 -4	Mar. 13, 1918	Aug. 26, 1918	100	26,005	23,913	1,165			

D-11	....do....	2	B-C	Encinitas	Las Flores	18.48	Oil surfacing			⅜			Feb. —, 1915	100	11,086	32,240	1,862		
39	....do....	2	C	Oceanside	....do....	8.03	15-foot concrete base.	4			1-2½-5	Sept. 24, 1913	Aug. 11, 1914	100	65,370	69,069	2,974		
D-187	....do....	2	C	At Las Flores Creek bridges.			Grading						May —, 1918	100	500	463			
D-237	....do....	2	C	San Margarita River bridge.		.08	....do....					June 11, 1919	Nov. —, 1919	100	2,300	2,378	7		
58	....do....	2	D	Las Flores	Westerly boundary.	11.14	15-foot concrete base.	4			1-2½-5	Apr. 22, 1914	July 20, 1915	100	99,207	107,160	8,032		
D-58	....do....	2	D	....do....	....do....	11.14	Oil surfacing			⅜			Dec. —, 1915	100	10,200	15,208	150		
D-80	....do....	2	D	....do....	....do....	.05	15-foot concrete base.	4			1-2½-5	Oct. 25, 1915	Feb. —, 1916	100	1,137	7,679	293		
	....do....						Surveying, total											14,560	372
59	....do....	12	A	East San Diego	La Mesa	1.96	15-foot concrete base.	4			1-2½-5	Apr. 22, 1914	Nov. 24, 1914	100	17,671	19,464	1,581		
217	....do....	12	A	Through East San Diego and La Mesa.		4.15	....do....	4			1-2 -4	Jan. 24, 1918	Aug. 26, 1918	100	53,604	56,241	2,012		
94	....do....	12	B	La Mesa	El Cajon	1.56	....do....	4			1-2½-5	Aug. 26, 1914	Feb. 25, 1915	100	16,312	16,880	952		
223	....do....	12	B	Through El Cajon		2.41	15 and 20 foot concrete base.	4			1-2 -4	Apr. 10, 1918	Aug. 26, 1918	100	33,185	31,470	1,219		
D-28	....do....	12	A-B	East San Diego	El Cajon	3.52	Oil surfacing			⅜		Jan. 22, 1915	Apr. —, 1915	100	3,099	5,006	561		
D-93	....do....	12	C	El Cajon	Flinn Springs	7.23	15-foot concrete base.	4			1-2½-5	Dec. 7, 1915	Aug. —, 1916	100	82,093	77,915	1,920		
D-120	....do....	12	C	Station 530	Station 698	3.18	Grading					Mar. 9, 1917	Feb. —, 1918	100	6,000	26,542	212		
D-181	....do....	12	C	Station 424 plus 34.48	Station 765 plus 58.	3.48	....do....					Jan. 16, 1918	Aug. —, 1917	100	10,000	20,567	904		
269	....do....	12	C-D	Flinn Springs	Ogden ranch	11.27	15-foot concrete base.	4			1-2 -4	May 26, 1920			237,971		168		
204	....do....	12	D	Guatan Creek	Pine Valley	4.55	Grading					Sept. 11, 1917	July 2, 1918	100	26,578	27,033	2,313		
219	....do....	12	D	3 miles east of Willows.	Sweetwater River.	3.74	....do....					Mar. 13, 1918	Jan. 23, 1919	100	68,571	74,357	2,738		
D-106	....do....	12	D	Guatan Creek	Pine Valley	2.36	....do....					July 26, 1916	Apr. —, 1917	100	26,000	26,011	828		
D-166	....do....	12	D	At Viejas Creek bridge and near station 177.			....do....					Oct. 6, 1917	Dec. —, 1917	100	1,350	774	8		
D-180	....do....	12	D	Station 45	Station 179	2.65	....do....					Jan. 16, 1918	Aug. —, 1918	100	15,000	10,801	387		
D-193	....do....	12	D	Sweetwater River bridge.			....do....					May 23, 1918	June 15, 1918	100	1,271	951	9		
263	....do....	12	E	Pine Valley	Casbere ranch	6.61	....do....					Jan. 5, 1920			71,272	31,135	2,240		
	....do....	12	E			.29	Surveyed												
D206	....do....	12	F	Station 178	Station 192 plus 56, Buckman Creek.	.28	Grading					Aug. 22, 1918	Nov. —, 1918	100	8,855	8,769	233		
264	....do....	12	F	Casbere ranch	Tecate Divide	13.80	....do....					Jan. 5, 1920			205,711	59,733	2,499		
D-231	....do....	12	G	Tecate Divide	Easterly boundary	15.21	15-foot concrete base.	4			1-2 -4	Apr. 10, 1919			381,522	333,160	6,724		
D-288	San Diego-Imperial. San Diego	12	H	(See contract D-288, Imperial, 12 H.)			Surveying, total											42,071	277
31	Ventura	2	A	Southerly boundary	Newbury Park	7.34	15-foot concrete base.	4			1-2½-5	May 21, 1913	June 23, 1914	100	69,859	75,164	4,126		
D-13	....do....	2	A	....do....	....do....	7.34	Oil surface and shoulders.			⅜			Jan. —, 1915	100	5,005	16,725	552		
261	....do....	2	A-B	Former east boundary.	Conejo grade	5.20	18-foot concrete base.	4			1-2 -4	Nov. 17, 1919			155,768	53,954	2,074		
81	....do....	2	B	Newbury Park	Springville	11.16	15-foot concrete base, oil surface.	4-6		⅜	1-2½-5	July 7, 1914	July 7, 1915	100	147,776	151,331	8,040		
175	....do....	2	B	Arroyo Calleguas	Bridge	.01	Concrete bridge					July 28, 1916	Nov. 21, 1916	100	5,103	4,514	678		Paid from motor-vehicle funds.
D171	....do....	2	B	Calleguas (Wash.) bridge.		.02	Channel protection					Nov. 17, 1917	Jan. 25, 1918	100	1,722	3,629	10		
171	....do....	2	C	Springville	Santa Clara River.	5.63	15-foot concrete base.	4			1-2½-5	July 10, 1916	May 22, 1917	100	58,298	46,407	2,931		
188	....do....	2	C	Santa Clara River	Ventura	4.16	....do....	4			1-2 -4	June 6, 1917	Nov. 19, 1917	100	40,805	43,029	3,041		
	....do....	2	C			10.20	Surveyed												
52	....do....	2	D-E	Ventura	Sea Cliff	8.02	15-foot concrete base.	4			1-2½-5	Feb. 26, 1914	Mar. 9, 1915	100	128,253	135,242	4,498		
D-34	....do....	2	D-E	....do....	....do....	8.02	Oil surfacing			⅜			June —, 1915	100	7,058	5,913	771		
	....do....	2	D			6.07	Surveyed												
	....do....	2	E			1.95	....do....												
D-1	....do....	2	F	Sea Cliff	Rancho El Rincon	1.29	Sea walls and trestle.					Sept. 28, 1912	June —, 1914	100	27,082	23,839	9,077		
73	....do....	2	E-G	Benham	Westerly boundary.	3.70	15-foot concrete base.	4			1-2½-5	June 9, 1914	June 1, 1915	100	54,819	71,091	3,468		
D-43	....do....	2	F-G	....do....	....do....	4.36	Oil surfacing			⅜			June —, 1915	100	3,200	2,991	572		
	....do....	2	G			.69	Surveyed												
	....do....						Surveying, total											20,547	208
	....do....	60	A			20.35												320	
	Total for Division VII.														7,339,220	6,280,758	289,885	246,905	2,624

[a] Unit base.

TABLE 3.—*Recapitulation of work-done schedule, giving payments made for construction, labor, and materials, including engineering, equipment, and administration charges.*

Divisions.	Preliminary estimate of cost, labor, and materials.	Payments made.													
		Actual payments, labor, and materials.	Engineering.						Legal.		Construction equipment.	Construction yards.	Miscellaneous equipment.[1]	Miscellaneous.[2]	Total not including equipment.	Total including equipment.
			Preliminary surveys.	Legal and general.	Field during construction.	Engineering equipment.	Overhead.		During construction.							
							Division.	Headquarters.	Division.	Headquarters.						
1	$3,541,403	$3,303,142	$229,753	$3,557	$171,089	$5,518	$60,637	$21,966	$28	$5,487	$29,878	$14,652	$43,839	$104,042	$3,899,701	$3,993,588
2	2,954,377	2,385,465	256,430	3,415	208,683	7,161	87,421	21,965	.....	5,486	28,312	6,999	57,919	124,089	3,092,954	3,193,345
3	5,724,521	5,876,803	272,628	5,843	299,076	6,094	75,521	21,966	8	5,486	18,352	4,414	102,663	142,049	6,669,380	6,830,903
4	4,670,555	4,475,375	242,530	12,457	291,677	6,083	72,776	21,966	27	5,487	15,590	55,777	53,501	138,000	5,260,295	5,391,246
5	4,372,462	4,276,459	166,592	3,804	187,923	5,434	63,267	21,966	12	5,487	23,357	4,269	78,637	128,864	4,854,374	4,966,071
6	3,853,791	3,605,482	166,147	2,641	164,953	5,576	72,068	21,966	24	5,487	16,109	.....	58,535	122,776	4,161,544	4,241,764
7	7,399,220	6,283,745	246,905	2,624	289,885	5,430	52,839	21,965	36	5,487	28,224	17,634	74,739	137,128	7,037,614	7,163,641
Total.	32,516,329	30,203,471	1,580,985	34,341	1,613,286	41,296	484,529	153,760	135	38,407	159,822	103,745	469,833	896,948	35,005,862	35,780,558

[1] Miscellaneous equipment includes:

Sand plants	$35,792
Powder magazines	10,655
Store accounts	64,834
Furniture and fixtures	42,337
Auto equipment	266,895
Camp equipment	25,279
Laboratory	5,351
Stable	17,712
Shop	978
Total	469,833

[2] Miscellaneous includes:

Purchasing department expenses	$22,883
Accounting department	221,904
General	559,940
Laboratory	39,907
Repairs to War Department equipment	52,314
	896,948

TABLE 4.—*Résumé estimated costs and payments made for labor and materials on contract and day-labor road construction work, by divisions, in California, to July 1, 1920.*

Division.	Preliminary estimates for projects.			Payments made on projects.		
	Completed.	In progress.	Total.	Completed.	In progress.	Total.
1	$1,591,439	$1,949,964	$3,541,403	$1,631,854	$1,671,288	$3,303,142
2	1,546,056	1,408,321	2,954,377	1,707,481	677,984	2,385,455
3	4,192,432	1,532,089	5,724,521	4,704,921	1,171,882	5,876,803
4	4,181,064	489,491	4,670,555	4,357,176	118,199	4,475,375
5	3,822,755	549,707	4,372,462	3,975,522	300,937	4,276,459
6	2,844,247	1,009,544	3,853,791	3,163,315	442,167	3,605,482
7	5,346,692	2,052,528	7,399,220	5,453,538	827,207	6,280,745
Total.	23,524,685	8,991,644	32,516,329	24,993,807	5,209,664	30,203,471

NOTE.—Percentage of cost of completed projects over estimate equals 6.24.

TABLE 5.—*Résumé estimated costs and payments made for labor and materials on contract road construction work, by divisions, in California, to July 1, 1920.*

Division.	Preliminary estimates for projects.			Payments made on projects.		
	Completed.	In progress.	Total.	Completed.	In progress.	Total.
1	$1,546,636	$591,059	$2,137,695	$1,574,928	$473,116	$2,048,044
2	1,471,386	843,978	2,315,364	1,629,113	453,849	2,082,962
3	3,431,316	605,785	4,037,101	3,650,372	217,952	3,868,324
4	3,542,705	290,785	3,833,490	3,802,976	.....	3,802,976
5	3,467,050	296,177	3,763,227	3,511,220	256,165	3,767,385
6	2,381,623	298,798	2,680,421	2,554,222	118,929	2,673,151
7	3,812,052	1,430,837	5,242,889	3,591,447	374,960	3,966,407
Total.	19,652,768	4,357,419	24,010,187	20,314,278	1,894,971	22,209,249

NOTE.—Percentage of cost of completed projects over estimate equals 3.36.

TABLE 6.—*Résumé estimated costs and payments made for labor and materials on day-labor road construction work, by divisions, in California, to July 1, 1920.*

Division.	Preliminary estimates for projects.			Payments made on projects.		
	Completed.	In progress.	Total.	Completed.	In progress.	Total.
1	$44,803	$1,358,905	$1,403,708	$56,926	$1,198,172	$1,255,098
2	74,670	564,343	639,013	78,368	224,135	302,503
3	761,116	926,304	1,687,420	1,054,549	953,930	2,008,479
4	638,359	198,706	837,065	554,200	118,199	672,399
5	355,705	253,530	609,235	464,302	44,772	509,074
6	462,624	710,746	1,173,370	609,093	323,238	932,331
7	1,534,640	621,691	2,156,331	1,862,091	452,247	2,314,338
Total.	3,871,917	4,634,225	8,506,142	4,679,529	3,314,693	7,994,222

NOTE.—Percentage of cost of completed projects over estimate equals 20.86.

PLATE V.

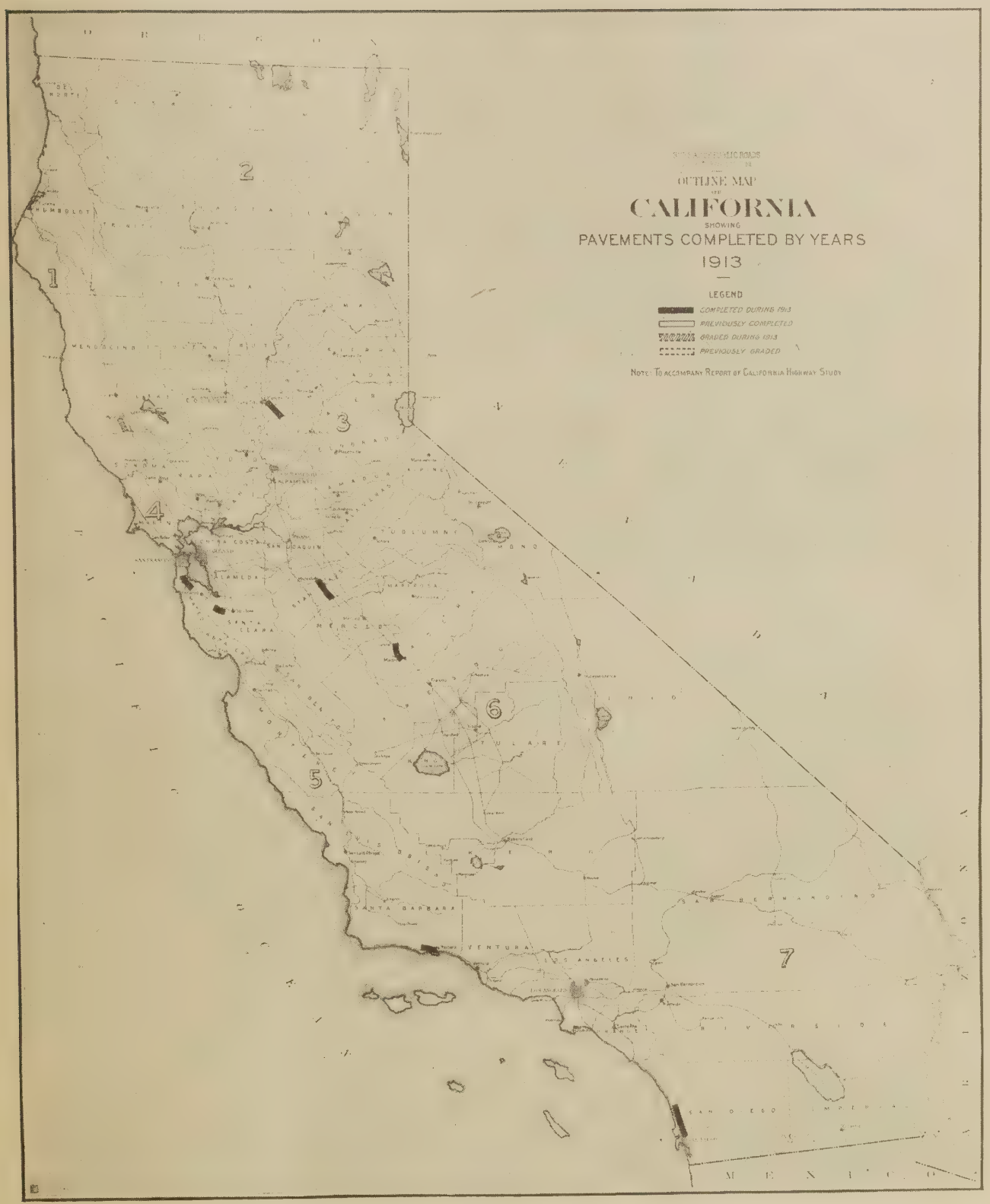

OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1913
LEGEND
COMPLETED DURING 1913
PREVIOUSLY COMPLETED
GRADED DURING 1913
PREVIOUSLY GRADED
NOTE: TO ACCOMPANY REPORT OF CALIFORNIA HIGHWAY STUDY
1
2
3
4
5
6
7
MEXICO

PLATE VI.


BUREAU OF PUBLIC ROADS
U.S. DEPT OF AGRICULTURE
OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1914
LEGEND
COMPLETED DURING 1914
PREVIOUSLY COMPLETED
GRADED DURING 1914
PREVIOUSLY GRADED
NOTE: TO ACCOMPANY REPORT OF CALIFORNIA HIGHWAY STUDY
1
2
3
5
6
7
MEXICO

PLATE VII.


BUREAU OF PUBLIC ROADS
U.S. DEPT. OF AGRICULTURE
OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1915
LEGEND
COMPLETED DURING 1915
PREVIOUSLY COMPLETED
GRADED DURING 1915
PREVIOUSLY GRADED
NOTE-TO ACCOMPANY REPORT OF CALIFORNIA HIGHWAY STUDY
1
2
3
4
5
6
7
DEL NORTE
SISKIYOU
MODOC
HUMBOLDT
TRINITY
SHASTA
LASSEN
TEHAMA
PLUMAS
MENDOCINO
GLENN
BUTTE
SIERRA
NEVADA
LAKE
COLUSA
YUBA
PLACER
SONOMA
NAPA
YOLO
SACRAMENTO
SAN JOAQUIN
ALPINE
AMADOR
CALAVERAS
CONTRA COSTA
OAKLAND
SAN FRANCISCO
ALAMEDA
TUOLUMNE
MONO
MARIPOSA
STANISLAUS
SANTA CLARA
SAN BENITO
MONTEREY
FRESNO
INYO
TULARE
KINGS
KERN
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
ARIZONA
MEXICO

PLATE VIII.


BUREAU OF PUBLIC ROADS
U.S. DEPT. OF AGRICULTURE
OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1916
LEGEND
COMPLETED DURING 1916
PREVIOUSLY COMPLETED
GRADED DURING 1916
PREVIOUSLY GRADED
NOTE: TO ACCOMPANY REPORT CALIFORNIA HIGHWAY STUDY
1
2
3
4
5
6
7
MODOC
SHASTA
LASSEN
TEHAMA
PLUMAS
SIERRA
NEVADA
PLACER
SACRAMENTO
ALPINE
AMADOR
CALAVERAS
TUOLUMNE
MONO
SAN JOAQUIN
CONTRA COSTA
ALAMEDA
SAN FRANCISCO
MARIPOSA
MADERA
FRESNO
INYO
TULARE
KERN
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
SAN DIEGO
IMPERIAL
MEXICO
ARIZONA

PLATE IX.


BUREAU OF PUBLIC ROADS
U.S. DEPT. OF AGRICULTURE
OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1917
LEGEND
COMPLETED DURING 1917
PREVIOUSLY COMPLETED
GRADED DURING 1917
PREVIOUSLY GRADED
NOTE.-TO ACCOMPANY REPORT OF CALIFORNIA HIGHWAY STUDY
OREGON
NEVADA
ARIZONA
MEXICO
1
2
3
4
5
6
7
SISKIYOU
MODOC
SHASTA
LASSEN
TEHAMA
PLUMAS
SIERRA
HUMBOLDT
TRINITY
MENDOCINO
BUTTE
YUBA
NEVADA
PLACER
EL DORADO
LAKE
COLUSA
SONOMA
NAPA
SACRAMENTO
ALPINE
AMADOR
CALAVERAS
TUOLUMNE
MONO
SAN FRANCISCO
OAKLAND
CONTRA COSTA
SAN JOAQUIN
ALAMEDA
MARIPOSA
SANTA CLARA
SAN BENITO
MONTEREY
MADERA
FRESNO
INYO
TULARE
KINGS
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
KERN
RIVERSIDE
ORANGE
SAN DIEGO
IMPERIAL

PLATE X.

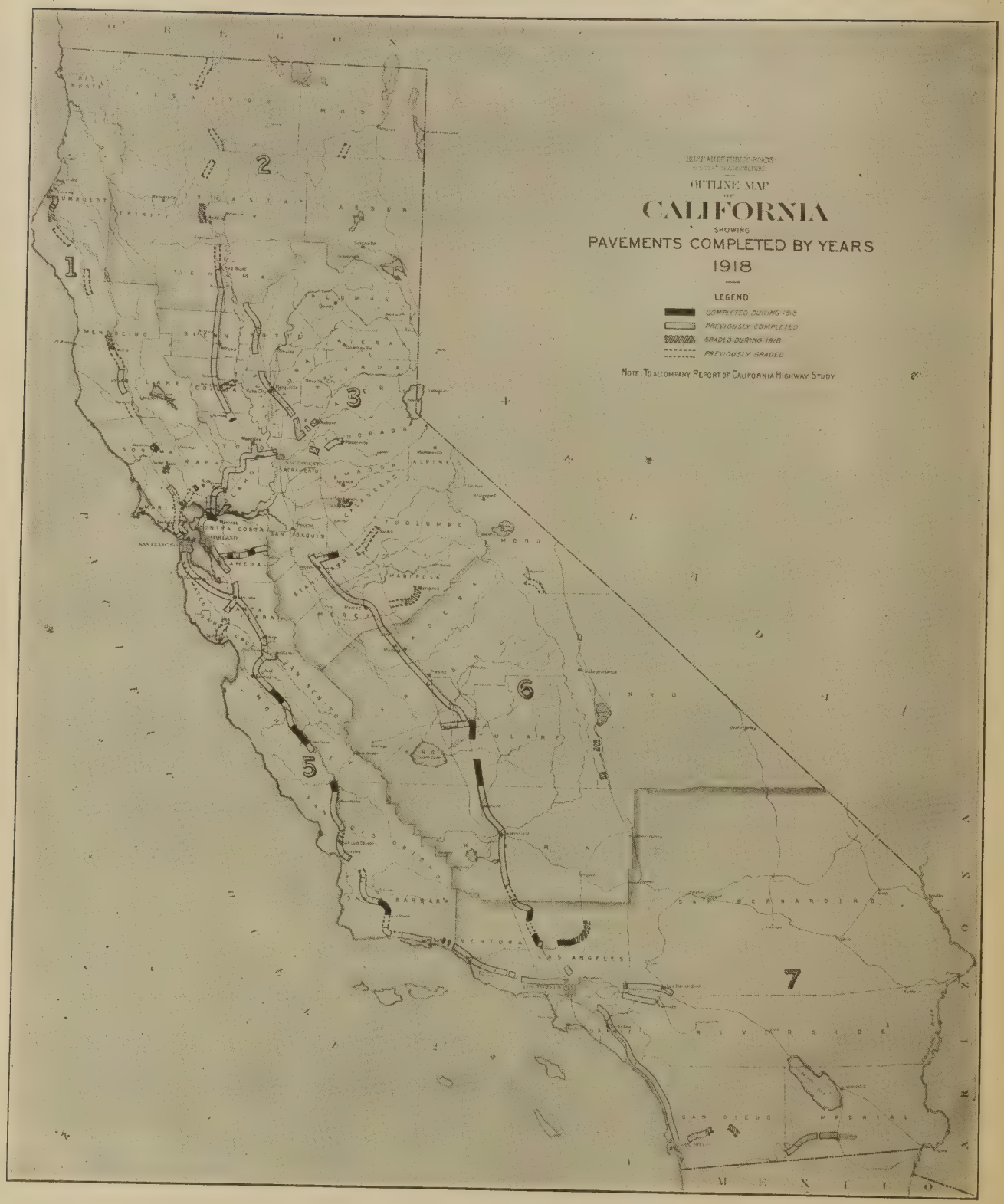
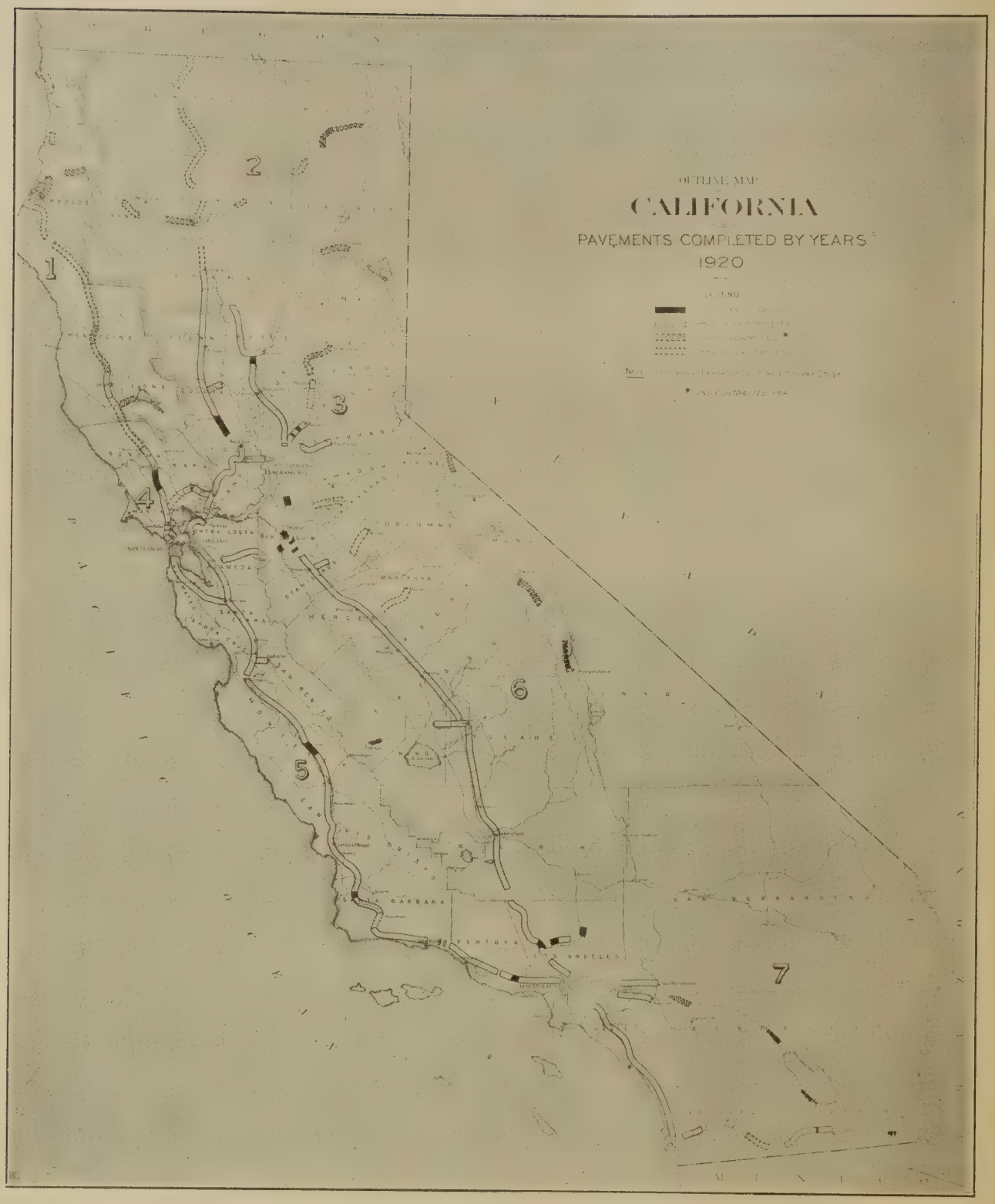

BUREAU OF PUBLIC ROADS
OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1918
LEGEND
COMPLETED DURING 1918
PREVIOUSLY COMPLETED
GRADED DURING 1918
PREVIOUSLY GRADED
NOTE.-TO ACCOMPANY REPORT OF CALIFORNIA HIGHWAY STUDY
1
2
3
5
6
7
MEXICO

PLATE XI.


BUREAU OF PUBLIC ROADS
U.S. DEPT. OF AGRICULTURE
OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1919
LEGEND
COMPLETED DURING 1919
PREVIOUSLY COMPLETED
GRADED DURING 1919
PREVIOUSLY GRADED
NOTE: TO ACCOMPANY REPORT CALIFORNIA HIGHWAY STUDY
OREGON
NEVADA
ARIZONA
MEXICO
1
2
3
4
5
6
7

PLATE XII


OUTLINE MAP
OF
CALIFORNIA
SHOWING
PAVEMENTS COMPLETED BY YEARS
1920
LEGEND
1
2
3
4
5
6
7

FEDERAL AID.

There follows, in Table 7, the details of all Federal-aid post road projects approved for construction up to November 1, 1920. Those projects completed are identified on the condition diagrams of Plates LXXIII to LXXXIV, inclusive, by their corresponding numbers. All Federal-aid projects completed or under construction are also included in the detail table of "work done."

"RIDGE ROUTE," 4 LOS ANGELES C. FEDERAL AID PROJECT NO. 13.

TABLE 7.—*California Federal aid projects, to Nov. 1, 1920.*

No.	Route.	County.	Section.	Length.	Type.	Agreement.		Date approved.	Status, per cent completed.
						Total estimates.	Federal aid.		
				Miles.					
1	2	San Mateo	B	4.24	5-inch concrete	$70,654.40	$35,327.20	Mar. 29, 1917	100
[1] 2									
[1] 3	14	Contra Costa	A	2.55	4½-inch concrete, 1½-inch top	54,723.66	24,244.56	Apr. 17, 1917	100
[1] 4									
[1] 5									
[2] 6									
7	20	Shasta	A–B	15.94	Earth	210,668.48	105,334.24	June 24, 1918	100
8	20	Trinity	D–E–F	11.40	do	310,984.30	155,492.15	June 2, 1919	89
9	12	San Diego	G	15.20	4-inch concrete and earth	[3] 273,492.03	[3] 121,913.95	Jan. 8, 1919	80
10	28	Modoc	A	10.85	Earth	78,717.65	39,358.82	June 2, 1919	40
11	10	Fresno	D	8.17	6-inch concrete	246,668.29	123,334.14	Aug. 29, 1919	100
12	18	Merced	A	14.89	4-inch concrete	266,667.85	133,333.92	Aug. 1, 1919	60
13	4	Los Angeles	B–C	17.62	4-inch reinforced concrete	[4] 310,388.10	136,404.64	Aug. 29, 1919	100
14	1	Mendocino	G–H	24.12	Earth	152,946.92	76,473.46	Aug. 1, 1919	100
15	2	Monterey	F	.50	Bridge	285,403.58	142,701.79	Sept. 11, 1919	99
16	1	Humboldt	J	2.80	Earth	39,471.56	19,735.78	Aug. 1, 1919	100
17	1	Del Norte	B	7.73	do	239,133.84	119,566.92	Aug. 11, 1919	82
18	1	Humboldt	G	7.43	4-inch concrete	151,646.96	75,823.48	Jan. 17, 1920	59
19	16	Mendocino	A	9.73	Earth	117,368.00	58,684.00	Aug. 29, 1919	100
20	16	Lake	A	9.36	do	116,708.02	58,354.01	Sept. 2, 1919	100
21	2	Ventura	A–B	5.19	Supplementary construction	166,885.40	83,442.70	Oct. 11, 1919	89
22	2	Los Angeles	C	1.29	(See note under summary)	42,310.40	21,155.20	do	100
23	2	do	A	5.23		100,070.85	50,035.42	do	100
24	2	Orange	B	9.37		139,889.31	69,944.65	Nov. 19, 1919	100
25	2	Santa Barbara	A	3.56	4-inch concrete	85,373.97	42,686.98	Nov. 18, 1919	100
26	4	Kern	A	10.73	4-inch reinforced concrete	329,598.61	164,799.30	do	51
27	13	Stanislaus	B	12.79	4-inch concrete	257,835.86	128,917.93	Dec. 10, 1919	90
28	17	Placer	C	6.68	do	137,303.70	68,651.85	do	[5]
29	34	Amador	B	10.74	Earth	71,828.59	35,914.29	do	[5]
30	13	Tuolumne	A–B	21.90	4-inch concrete				[6]
31	1	Del Norte	B	4.08	Gravel	37,136.70	18,568.35	Jan. 17, 1920	55
32	3	Siskiyou	B	17.64	4-inch concrete	422,063.13	211,031.56	Feb. 26, 1920	[7]
33	26	San Bernardino	B–A	7.10	Earth	107,054.79	53,527.39	Feb. 18, 1920	100
34	12	San Diego	E	6.61	do	78,399.04	39,199.52	do	82
35	12	do	F	13.80	do	224,649.11	112,324.55	do	73
36	1	Humboldt	F	7.34	Concrete				[5]
37	10	Fresno	E	11.99	4-inch reinforced concrete				[5]
38	18	Mariposa	D	7.84	Grading				[5]
39	26	Riverside	G	14.33	4-inch reinforced concrete	356,735.53	178,367.76	May 12, 1920	17
40	28	Shasta	A–B	16.84	Grading				[5]
41	26	Imperial	E	14.86	4-inch reinforced concrete	355,389.46	177,694.73	May 24, 1920	12
42	3	Tehama	D	15.17	do				[5]

[1] Disapproved by Secretary.
[2] Project withdrawn.
[3] Grading, $15,827.90; concrete, $257,664.13.
[4] Final cost, $272,809.28.
[5] Deferred.
[6] Project statement approved.
[7] Not started.

TABLE 7.—*California Federal aid projects, to Nov. 1, 1920*—Continued.

No.	Route.	County.	Section.	Length.	Type.	Agreement.		Date approved.	Status, per cent completed.
						Total estimates.	Federal aid.		
				Miles.					
43	18	Mariposa	H	1.28	Grading	$38,004.14	$19,002.07	May 12, 1920	99
44	7	Yolo	B	10.71	5-6 inch reinforced concrete	278,320.60	139,160.30	Sept. 8, 1920	51
[2] 45	20	Humboldt	C	12.78	Grading			do	[2]
46	1	do	D-E	17.96	Reinforced concrete				[5]
47	18	Mariposa	E	9.39	Grading				[5]
48	5	Santa Clara	B	8.09	4½-inch concrete	190,439.45	95,219.72	do	[2]
49	5	Santa Cruz	A	5.53	do	139,146.15	69,573.07	do	45
50	10	Fresno	F	8.07	4-inch reinforced concrete				[5]
51	12	San Diego	C	6.67	do	161,110.26	80,555.13	Sept. 8, 1920	[7]
52	1	Mendocino	D-E-F	17.80	do	441,263.84	220,631.92	do	2
53	18	Mariposa	F	7.27	Grading				[5]
54	18	do	G	5.69	do				[5]
55	12	San Diego	D	4.59	4-inch reinforced concrete	119,412.48	59,706.24	Sept. 8, 1920	14
56	3	Shasta	A	15.67	4-inch concrete				[5]
57	3	Tehama	C	13.60	4-inch reinforced concrete				[5]
58	2	Santa Barbara	D-E	14.64	5-inch reinforced concrete				[5]
59	33	San Luis Obispo	A	11.54	4-inch concrete				[5]
60	23	Mono	H	13.41	Grading				[5]
61	21	Butte	A	.23	Steel bridge				[5]
62	15	Sutter	B	5.95	5-inch reinforced concrete				[5]
63	10	Kings	B	12.40	do				[5]

SUMMARY.

	Miles.	Agreement.		Remarks.
		Estimated cost.	Federal aid.	
Concrete pavement	221.34	$5,081,562.40	$2,504,041.40	24.41 miles complete, 154.81 miles under construction, 96.30 miles reenforced concrete, 42.12 miles construction not started.
Graded earth	135.26	1,801,762.34	900,881.15	124.52 miles under construction, 10.74 miles grading not started.
Bridges	[8]	285,493.58	142,701.79	One under construction, one not started.
Gravel	4.08	37,136.70	18,568.35	4.08 miles under construction.

[2] Project withdrawn. [5] Deferred. [7] Not started. [8] One bridge.

NOTE.—Project statements have been approved but plans, specifications, and estimates have not been submitted for projects for which amount is not shown under agreement.

1. Tabulation includes only pavements for which agreements have been executed.
2. Type of pavement and reinforcing shown is based on plans approved by Secretary of Agriculture.
3. Of total mileage of concrete 9.25 miles is 6 inches in thickness.
   Of total mileage of concrete 15.47 miles is 5 inches in thickness.
   Of total mileage of concrete 19.48 miles includes rebuilding and supplementary construction of old 15-foot pavement.
4. Reinforcing has been added during construction on following projects: 9, 12, 26, 39, 41, 48, 49, 27 (1 mile).
5. Concrete on all pavements under construction has been increased to 5 inches reinforced, effective about October 15.
6. No. 21: From station 0+00 to 96+00, Section A, and station 30+00 to 124+00, Section B, on a concrete road 15 feet wide and 4 inches thick, with worn macadam shoulders, was placed an additional 4 inches of reinforced concrete extending also over the macadam shoulders to a total width of 18 feet, and from station 124 to station 208, 5 inches of reinforced concrete, 20 feet wide, was placed on a roadbed which had never been surfaced. No. 22: Reinforced concrete pavement 4 inches thick and 18 feet wide upon an old concrete pavement 15 feet wide with macadam shoulders, same as No. 21. No. 23: On a concrete pavement 15 feet wide and 4 inches thick with 3-foot macadam shoulders, was placed a reinforced concrete pavement 4 inches thick and 20 feet wide extending over the shoulders from station 167+00 to station 237+00. From station 0+0 to station 167+00 and from station 237+00 to station 276+00, was placed a 1½-inch thick Topeka surface on top of the old concrete pavement and shoulders. No. 24: To a concrete pavement 4 inches thick and 15 feet wide with earth shoulders were added concrete shoulders 2½ feet wide and 6 inches thick, and between station 300+00 and Station 494+60 an asphalt wearing surface 15 feet wide and 1½ inches thick on top of the old concrete pavement.

BRIDGES AND STRUCTURES.

In the first biennial report in 1918 is a statement regarding bridges substantially as follows:

In 1912 the California Highway Commission requested the counties to provide bridges. As a result, the greater part of the new bridges on the State highway have been built by the counties or their cost has been paid wholly or in part by the counties. The bridges represent a very material contribution toward the financing of the State highways, roughly estimated to be at least $3,000,000. The counties have not reported the cost of bridges.

The California Highway Commission set forth its general policy in respect to bridges in a vote adopted in September, 1912, as follows:

"(*a*) All such structures are to be designed by competent engineers and the plans, specifications, and workmanship are to be subject to the inspection and approval of the highway engineer of the department of engineering.

"(*b*) The width of such structures, exclusive of sidewalks, if any, shall not be less than 21 feet in the clear.

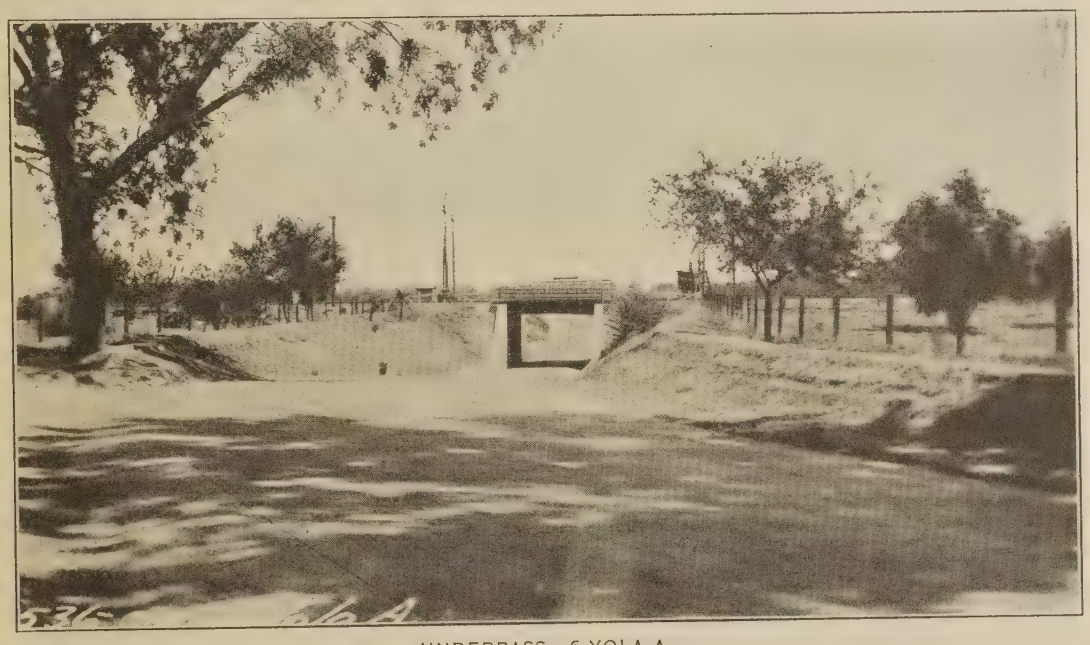
"(*c*) Concrete bridges shall be designed to sustain, in addition to the dead load, a uniform live load of 150 pounds per square foot of roadway and the floor system to carry a 20-ton traction engine.

"(*d*) Steel bridges of spans less than 150 feet shall be designed to sustain, in addition to the dead load, a uniform live load of 100 pounds per square foot of roadway, and the floor system to carry a 15-ton road roller; for spans in excess of 150 feet, a uniform live load of 85 pounds per square foot of roadway, the floor system to carry a 15-ton road roller as in the case of spans less than 150 feet.

"(*e*) Trestles shall be designed to sustain, in addition to the dead load, a uniform live load of 150 pounds per square foot of roadway and the floor system to carry a 15-ton road roller.

"Further, that the commission hereby declares itself in favor of concrete structures whenever such structures are consistently possible because of their substantial permanency."

It became evident that to design long-span concrete bridges for a live load of 150 pounds per square foot required unnecessarily expensive structures. Owing to the rapid increase in the weights of motor vehicles, it appeared that a 20-ton tractor was none too heavy a load for the floor systems of steel bridges as well as concrete bridges. Also, the abrupt jump in loading from 100 pounds per square foot to 85 pounds per square foot at a span length of 150 feet led to inconsistencies in the strength required in bridges of only slightly different lengths. The concensus of opinion among prominent writers on the design of highway bridges favors a live-load requirement which gradually decreases as the length of the span increases. As a result of these considerations it has become the practice to design both steel and concrete bridges of spans less than 50 feet and the floor systems of all bridges for the 20-ton tractor or 150 pounds per square foot, and long-span bridges for a 20-ton load assumed to occupy an area of 8 by 15 feet, together with a uniform load of 60 pounds per square foot on the remaining floor area. These loadings are also recommended to the counties.

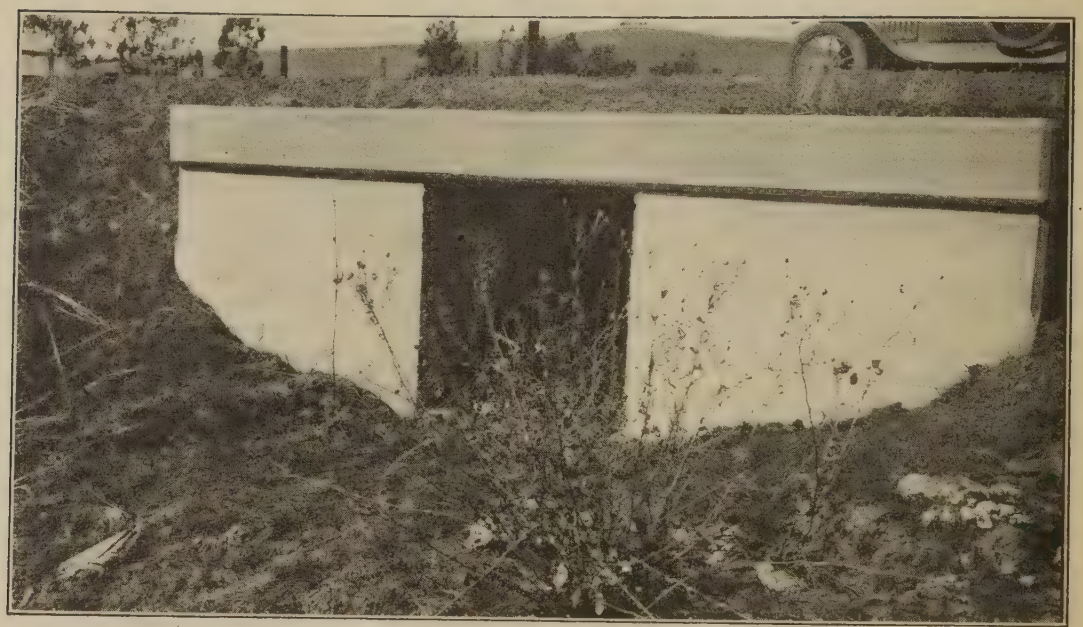


UNDERPASS. 6 YOLA A.

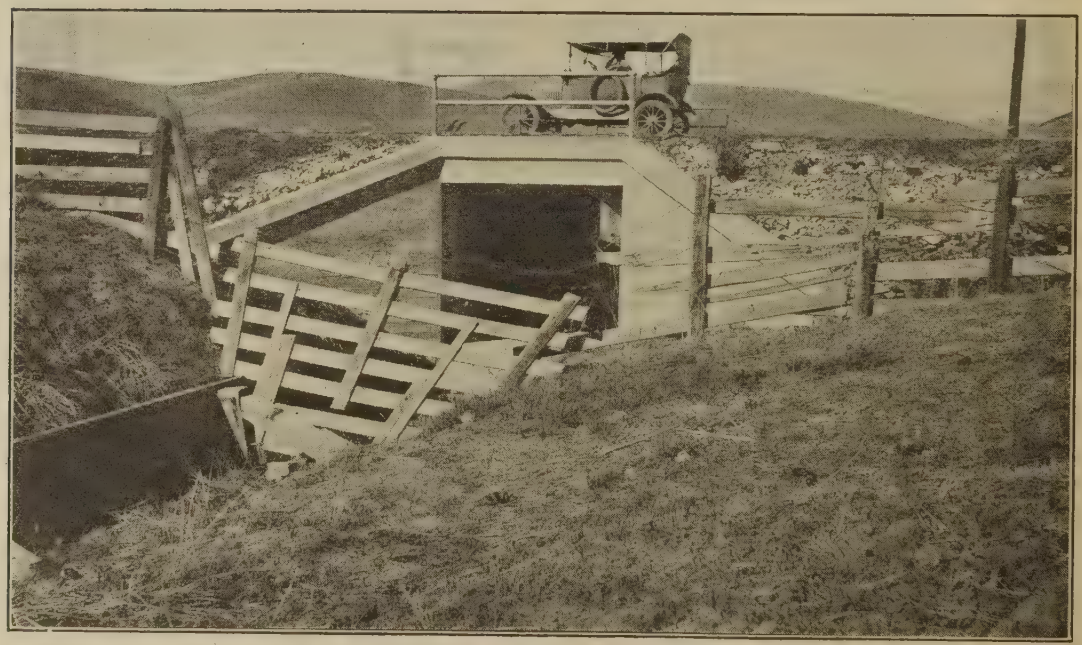
The initial organization of the California Highway Commission did not include a bridge department, so that when bridge work began to develop it fell to the lot of the office engineer at the headquarters office to carry it on. This arrangement has continued to date, and a squad organization in the headquarters office has developed as a result, with an assistant engineer and from two to three draftsmen almost constantly employed on bridge work.

Nearly 250 sets of plans for county bridges have been checked and over 100 structures have been designed by the highway commission forces. Seventy structures, other than short-span bridges and culverts built from standard plans, have been built or are being constructed under the direct control and supervision of the California Highway Commission. In a number of cases the commission has furnished inspectors for bridges built by the counties. The construction work is carried on by the same division organizations which handle the road work. The commission has furnished plans and handled construction for bridges paid for wholly by counties and jointly by the State and counties. It has handled construction for the counties at their expense and from plans furnished by them. It has furnished plans and specifications from which counties have built the bridges. The total cost of bridges constructed under the

PLATE XIII.



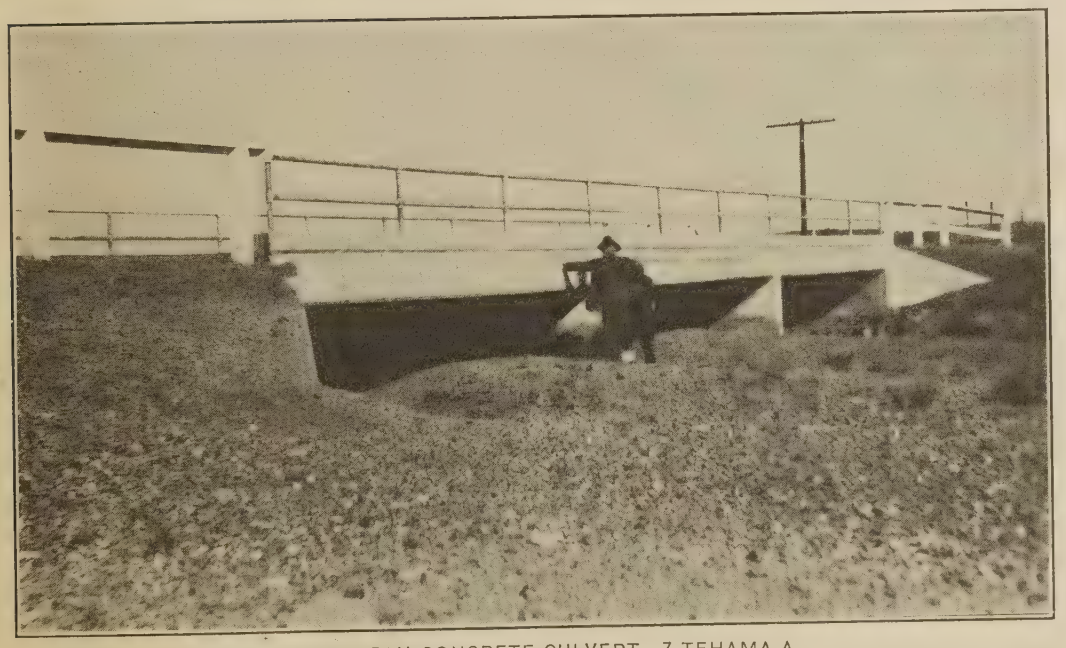
CONCRETE BOX CULVERT 5 ALAMEDA B



CONCRETE CULVERT. 5 ALAMEDA B.

PLATE XIV.

YOLO CAUSEWAY.



THREE-SPAN CONCRETE CULVERT. 7 TEHAMA A.

direct supervision of the commission amounts to nearly $1,400,000.

Short descriptions of a number of bridges of various types constructed on the State highways since 1912 are given in the report. The prevailing type is the short-span reinforced-concrete girder.

On the whole, the results of this cooperation (with the county) have been fairly satisfactory, but in some instances a disposition to build bridges according to the practices prevalent before the development of present-day traffic conditions has manifested itself. In a few cases it has been impossible to prevail upon those responsible to change their ideas and build for present-day traffic, with the result that there are some new bridges on the line of the State highways which are not up to the usual standard. While these have never been officially taken over as part of the State highways and the commission disclaims responsibility for them, yet they constitute a part of the traffic route and may easily become a source of embarrassing controversies in the future.

At present the required uniform live load for the floors of steel bridges, trusses, and girders less than 60 feet long and for concrete bridges, except earth-filled arches, is 125 pounds per square foot. For earth-filled arches 150 pounds per square foot is assumed. The uniform live load for girders and trusses is gradually reduced from 125 to 100 pounds per square foot, for spans between 60 and 100 feet long, and further reduced from 100 to 70 pounds for spans from 100 to 250 feet long.

The present specification provides for the concentrated load of a 20-ton motor truck, and the maximum stress from either the uniform or concentrated load is to be used. For floor beams two trucks are used. The unit stresses are increased 15 per cent for this condition.

From a study of design loading in use by 36 of the State highway departments, it is found that, while the California assumptions are not as high as those used by some of the State highway departments, they are from 10 to 20 pounds per square foot above the average for uniform loads for spans less than 200 feet long and less than the average for spans over 240 feet long, and about as high as any for concentrated loads.

The bridges and drainage structures built by the State highway commission are in general adequate and well designed and constructed. Some of the larger structures are of noteworthy elegance in design. The Yolo Causeway, 3.13 miles in length, is probably the boldest highway structure of its kind in America. It is to be noted that many streams in the flat valleys demand bridges of excessive length to provide for flood stages. Consistent efforts appear to have been made to eliminate dangerous grade crossings, but much remains to be done.

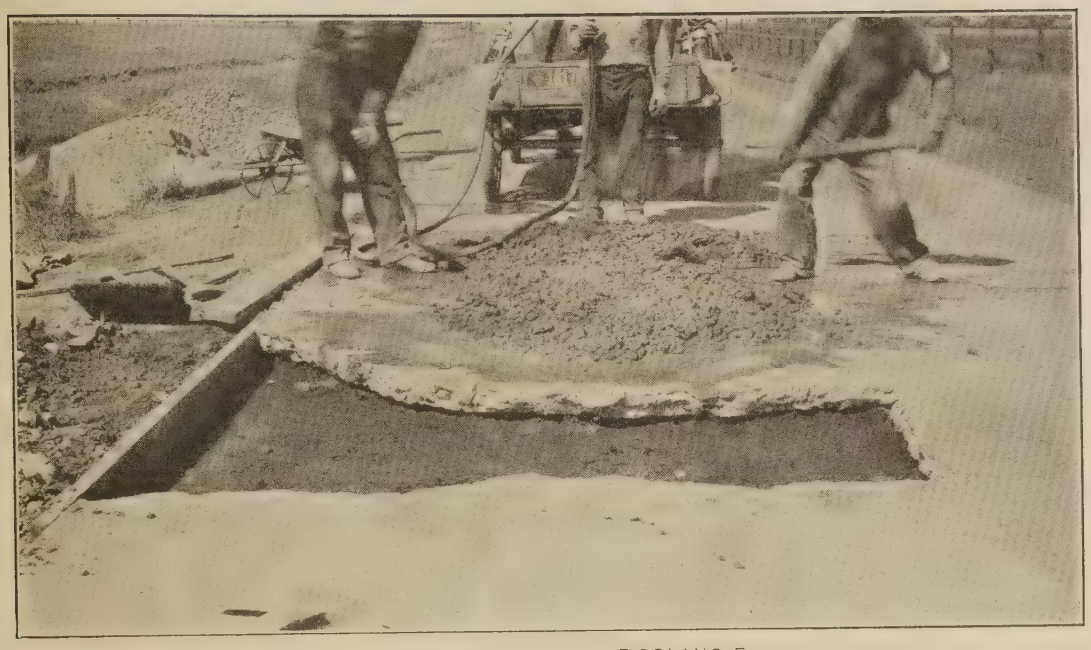
MAINTENANCE.

The books of the commission show a total expenditure for maintenance from the motor-vehicle fund of $5,780,550.92. The items making up this amount are shown in the reconciliation, Table 8, and by State divisions in the recapitulation, Table 9, of which Schedule J following is a part.

TABLE 8.—*Reconciliation of highway maintenance schedule, California, with statement of condition of funds, July 1, 1920.*

Total direct charges to highway maintenance per divisional sheet		$4,276,211.77
Undistributed charges including:		
(1) Injuries to employees	$15,328.17	
(2) General expense	49,463.84	
(3) Maintenance of plant	17,947.78	
(4) Repairs to motor vehicles	146,208.49	
(5) Repairs to other equipment	62,732.34	
Undistributed overhead, removed from direct charges by analysis since July 1, 1920	24,828.55	
		316,509.17
Highway maintenance, direct charges, per statement of condition		4,592,720.94

It will be noted that the total of the so-called "direct charges"—exclusive of equipment—amounts to $4,276,212, so that the indirect charges, equipment and overhead, amount to $1,504,339. Of this latter amount, however, $613,729 was spent for equipment, much of which is available for use on future maintenance. Deducting this item, there remains $890,610 gross indirect charges and overhead. It is believed fair to assume that there is equipment on hand to the value of $500,000 and that the direct charge should be increased by the difference of $113,729. There is a stores account of $26,419 and a county expense item of $21,893, neither of which should be charged against maintenance work already done. Deducting the total of these two items or $48,312 from the gross indirect charges and overhead, there results $842,298, or an addition of about 19.2 per cent of the direct charges and depreciation on equipment. The overhead is 12.5 per cent. This percentage seems high for maintenance work and indicates the advisability of study to secure a more economical handling of this branch of the commission's activities. The direct charges, not including depreciated equipment, are: General maintenance proper, $2,470,836; improvement, $1,577,691 (which is a construction item); and reconstruction, $227,685. The true corresponding direct maintenance costs are the sum of the general maintenance and these reconstruction charges, or $2,698,521, and to this must be added a corresponding percentage of depreciated equipment amounting to $71,763, also 19.2 per cent for indirect charges and overhead. In like manner the improvement cost of $1,577,691 must be increased by $41,966 and by 19.2 per cent, which would bring it up to a total of $1,930,631.



PATCHING CONCRETE. 7 SOLANO E.

FENCED REPAIR JOB. 4 KERN C.

TABLE 9.—*Recapitulation of maintenance costs.*

Division.	Direct charges.				Indirect charges.										Grand total.
	Total.	General.	Improvements.	Reconstruction.	Total.	Oiling plants.	Maintenance yards.	Maintenance equipment.[1]	Auto equipment.	Camp equipment.	Shop equipment.	County expense.	Miscellaneous.[2]	Miscellaneous overhead.[3]	
1	$445,611	$222,810	$222,301	$500	$159,726	.....	$7,368	$25,528	$12,601	$585	$37	.....	$41,766	$71,841	$605,337
2	411,392	135,864	275,486	42	127,206	$3,332	4,250	18,195	10,008	1,210	29	.....	41,668	48,514	538,598
3	984,459	672,298	237,959	74,202	311,999	18,891	20,921	51,662	43,244	1,370	8,605	$10,531	53,507	103,268	1,296,458
4	718,989	455,935	248,035	15,019	253,735	7,073	28,267	39,213	32,927	184	2,328	11,362	45,697	86,684	972,724
5	410,051	263,316	145,440	1,295	153,078	1,952	6,031	15,688	18,750	2,275	320	.....	41,908	66,154	563,129
6	369,001	257,943	83,949	27,109	208,508	16,599	28,638	20,367	41,295	125	1,502	.....	42,696	57,286	577,509
7	936,709	462,670	364,521	109,518	290,087	6,078	34,358	41,738	35,158	1,764	3,262	.....	50,858	116,871	1,226,796
Total	4,276,212	2,470,836	1,577,691	227,685	1,504,339	53,925	129,833	212,391	193,983	7,513	16,083	21,893	318,100	550,618	5,780,551

[1] Maintenance equipment includes maintenance construction equipment, $210,349; engineering equipment, $89; furniture and fixtures, $346; stable equipment, $638; and patrolmen houses, $929.

[2] Miscellaneous includes stores accounts, $26,419; miscellaneous charges, $291,681; which is made up of undistributed charges as follows: Injuries to employees, $15,328; general expense, $49,454; maintenance of plants, $17,948; repairs to motor vehicles, $146,208; and repairs to other equipment, $62,732.

[3] Miscellaneous overhead includes $525,789 administrative expenses; for salaries, office supplies, traveling expenses, and general expenses (see Schedule J), and undistributed charges removed by analysis since July 1, 1920, $24,829.

TABLE 9.—*Schedule J—Details of administrative expense, motor-vehicle fund, maintenance schedule, by departments, for headquarters and divisions.*

	Total headquarters and divisions.	Headquarters.	All divisions.	Division I.	Division II.	Division III.	Division IV.	Division V.	Division VI.	Division VII.
Engineering department:										
Salaries	$199,932.77	$42,159.06	$157,773.71	$20,315.99	$8,556.49	$37,901.14	$27,663.06	$16,439.86	$12,899.19	$33,997.98
Office supplies	11,204.34	6,104.48	5,099.86	1,231.27	531.46	434.82	1,005.93	459.61	317.85	1,118.92
Traveling expenses	11,681.52	1,907.65	9,773.87	2,585.67	549.18	869.62	1,341.24	707.09	1,138.94	2,582.13
Commissary	1,364.03	.....	1,364.03	205.22	17.72	.....	167.65	106.07	264.87	602.50
Hotel	1,791.92	.....	1,791.92	492.50	70.86	217.40	335.31	424.25	79.46	172.14
Stable	1,317.38	.....	1,317.38	246.26	141.71	144.94	223.55	282.83	105.95	172.14
Maintenance	1,101.48	.....	1,101.48	123.13	53.14	217.40	279.42	176.78	79.47	172.14
Total	228,393.44	50,171.19	178,222.25	25,200.04	9,920.56	39,785.32	31,016.16	18,596.49	14,885.73	38,817.95
Legal department:										
Salaries	9,919.79	9,919.79	.....	.....	.....	.....	.....	.....	.....	.....
Fees	763.05	763.05	.....	.....	.....	.....	.....	.....	.....	.....
Traveling expenses	1,716.88	1,716.88	.....	.....	.....	.....	.....	.....	.....	.....
Total	12,399.72	12,399.72	.....	.....	.....	.....	.....	.....	.....	.....
Purchasing department, salaries	7,821.36	7,821.36	.....	.....	.....	.....	.....	.....	.....	.....
Accounting department, salaries	81,013.47	26,707.10	54,306.37	6,607.83	1,913.25	13,914.00	11,009.34	6,434.53	4,529.28	9,898.14
General expense:										
Fixed charges	37,957.38	11,255.13	26,702.25	1,641.69	956.63	5,072.80	6,091.46	1,909.15	1,562.73	9,467.79
Stationery and supplies	24,389.19	17,359.62	7,029.57	820.85	513.74	1,376.90	726.50	671.73	423.79	2,496.06
Telephone and telegraph	14,166.95	3,052.24	11,114.71	1,477.52	194.87	1,594.31	1,620.66	1,202.05	635.69	4,389.61
Postage and express	10,299.98	4,196.83	6,103.15	779.81	230.30	797.16	894.16	601.04	476.77	2,323.91
Auto maintenance	48,277.10	9,538.25	38,738.85	4,227.37	3,968.22	9,203.55	3,464.87	3,818.29	3,814.13	10,242.42
Traveling expense	8,584.43	8,584.43	.....	.....	.....	.....	.....	.....	.....	.....
General office salaries	40,658.30	27,851.68	12,806.62	287.29	17.71	724.68	1,061.81	2,121.27	158.92	8,434.94
Highway bulletin	1,144.59	1,144.59	.....	.....	.....	.....	.....	.....	.....	.....
Total	185,477.92	82,982.77	102,495.15	9,234.53	5,881.47	18,769.40	13,859.46	10,323.53	7,072.03	37,354.73
Laboratory:										
Salaries	8,775.19	8,775.19	.....	.....	.....	.....	.....	.....	.....	.....
Supplies	1,144.60	1,144.60	.....	.....	.....	.....	.....	.....	.....	.....
Traveling expense	763.05	763.05	.....	.....	.....	.....	.....	.....	.....	.....
Total	10,682.84	10,682.84	.....	.....	.....	.....	.....	.....	.....	.....
Grand total	525,788.75	190,764.98	335,023.77	41,042.40	17,715.28	72,468.72	55,884.96	35,354.55	26,487.04	86,070.82

"General maintenance," in the words of the State highway commission, covers "maintenance in present condition and making of minor repairs"; "Reconstruction" covers "rebuilding with original type over large areas," and "Improvement" covers "new or additional construction or betterment, and including changes in line, grade, or type of construction."

Table 10 shows total consolidated maintenance expenditures by types; following this are Tables 11 to 17, inclusive, which show the expenditures for maintenance of the various types by divisions. None of these tables, however, shows any of the indirect or overhead charges, and in each case approximately 22.12 per cent must be added to obtain final costs.

The records on file in the office of the State highway commission give maintenance costs in considerable detail, and it is possible to get total and yearly maintenance unit costs for the different types. For example, the average maintenance cost of 15-foot by 4-inch concrete base, not oiled, has been $0.006 per square yard per year and for 15-foot by 4-inch concrete base with ⅜-inch oil top, $0.009 per square yard per year. In special cases the maintenance has exceeded these figures. These costs are for the items mentioned alone and do not include other items, such as shoulders, ditches, roadsides, etc.

There are also given, in Tables 18 and 19, detailed costs of maintenance and improvement of 32.45 miles of oil macadam pavement as well as the first cost of construction of this mileage.

TABLE 10.—*Total motor-vehicle fund expenditure, highway maintenance schedule; all divisions consolidated by types.*

Types.	Miles.	Total.	General maintenance.	Improvement.	Reconstruction.
Earth and gravel	1,524.17	$1,302,659.00	$764,896.64	$533,493.22	$4,269.14
Oiled earth	23.72	29,732.75	19,469.56	10,172.08	91.11
Oil macadam	187.03	406,897.23	292,347.82	53,039.50	61,509.91
Plank trestle	.44	386.63	386.63		
Pile trestle	1.24	3,039.64	3,039.64		
Oiled plank road	20.80	86,308.77	16,224.01	70,084.76	
Asphalt on plank	.43	461.02	461.02		
Topeka on plank	.57	4,070.21	983.43	1,416.63	1,670.15
Topeka on macadam	16.18	56,618.18	23,148.42	31,030.94	2,438.82
Concrete base	868.66	1,044,254.12	619,503.33	386,735.69	38,015.10
Oiled concrete	557.71	1,010,205.63	599,752.22	298,400.35	112,053.06
Topeka on concrete	67.10	278,327.89	87,891.49	187,384.05	3,052.35
Asphalt on concrete	8.08	20,767.12	15,893.29	3,138.62	1,735.21
Willite on concrete	1.00	1,283.05	764.81	518.24	
Bitucrete on concrete	.89	1,332.12	265.22	219.73	847.17
Asphalt concrete	15.06	29,868.41	25,807.84	2,054.52	2,006.05
Total	3,293.00	4,276,211.77	2,470,835.37	1,577,688.33	227,688.07

TABLE 11.—*Total earth and general maintenance charges, by divisions.*

Division.	Miles.	Total.	General.	Improvement.	Reconstruction.
1	178.10	$373,378.52	$192,347.81	$180,530.71	$500.00
2	367.67	404,789.79	129,260.85	275,486.94	42.00
3	656.73	275,196.07	253,065.32	22,130.75	
4	61.25	135,924.37	91,511.18	44,413.19	
5	25.49	37,122.07	26,190.44	10,931.63	
6	122.79	33,996.97	32,313.62		1,683.35
7	112.14	42,251.21	40,207.42		2,043.79
Total	1,524.17	1,302,659.00	764,896.64	533,493.22	4,269.14

TABLE 12.—*Total oiled earth maintenance charges, by divisions.*

Division.	Miles.	Total.	General.	Improvement.	Reconstruction.
1					
2					
3	4.00	$5,954.13	$5,954.13		
4					
5	3.86	18,828.84	8,565.65	$10,172.08	$91.11
6	15.86	4,949.78	4,949.78		
7					
Total	23.72	29,732.75	19,469.56	10,172.08	91.11

TABLE 13.—*Total oil macadam maintenance charges, by divisions.*

Division.	Miles.	Total.	General.	Improvement.	Reconstruction.
1	7.73	$16,577.11	$15,599.41	$977.70	
2					
3	96.10	270,044.02	170,662.83	46,468.77	$52,912.42
4	5.42	15,806.58	14,162.43	401.89	1,242.26
5	12.67	43,535.04	38,863.18	4,671.86	
6	10.00	4,532.28	4,098.28	433.32	
7	55.11	56,402.20	48,961.01	85.96	7,355.23
Total	187.03	406,897.23	292,347.82	53,039.50	61,509.91

TABLE 14.—*Total concrete base maintenance charges, by divisions.*

Division.	Miles.	Total.	General.	Improvement.	Reconstruction.
1	4.32	$48,141.53	$10,740.01	$37,401.52	
2	49.68	5,796.89	5,796.89		
3	258.11	176,897.13	139,495.31	31,507.95	$5,893.87
4	110.16	222,617.77	158,864.41	59,874.01	3,879.35
5	149.11	150,689.35	93,237.21	56,945.09	507.05
6	118.86	111,252.13	89,866.43	18,889.73	2,495.97
7	178.42	328,859.32	121,503.07	182,117.39	25,238.86
Total	868.66	1,044,254.12	619,503.33	386,735.69	38,015.10

TABLE 15.—*Total oiled concrete maintenance charges, by divisions.*

Division.	Miles.	Total.	General.	Improvement.	Reconstruction.
1	4.83	$7,513.57	$4,124.26	$3,389.31	
2	3.23	805.12	805.12		
3	105.90	180,652.79	90,504.15	78,765.71	$11,382.93
4	68.76	143,211.78	97,726.53	41,184.78	4,300.47
5	68.09	123,710.45	72,106.61	50,907.23	696.61
6	136.95	198,907.06	119,335.75	56,641.25	22,930.06
7	169.95	355,404.86	215,149.80	67,512.07	72,742.99
Total	557.71	1,010,205.63	599,752.22	298,400.35	112,053.06

TABLE 16.—*Total Topeka-on-concrete maintenance charges, by divisions.*

Division.	Miles.	Total.	General.	Improvement.	Reconstruction.
1					
2					
3	6.09	$63,547.56	$7,161.54	$56,005.11	$380.91
4	32.37	123,246.06	54,264.44	67,600.57	1,381.05
5	6.13	14,343.20	2,531.11	11,812.09	
6	6.38	15,362.86	7,377.84	7,985.02	
7	16.13	61,828.21	16,556.56	43,981.26	1,290.39
Total	67.10	278,327.89	87,891.49	187,384.05	3,052.35

TABLE 17.—*Total asphaltic concrete maintenance charges, by divisions.*

Division.	Miles.	Total.	General.	Improvement.	Reconstruction.
1					
2					
3	2.33	$7,636.17	$4,007.84	$1,665.16	$1,963.17
4	.18	796.58	364.34	389.36	42.88
5	12.55	21,435.66	21,435.66		
6					
7					
Total	15.06	29,868.41	25,807.84	2,054.52	2,006.05

TABLE 18.—*Detailed cost of maintenance and improvement of 32.45 miles of oil-macadam pavement, distributed by items.*

	County, route, section.	Number of square yard-years.	Total.	PB.	BS.	S.	CD.	GR.	G.	RS.	T.	GE.	Pat.
General maintenance	Mendocino, 1, C	402,500	$15,599	$642	$11,322	$324	$1,659	$268	.....	$1,330	$16	$38	.....
	Eldorado, 11, B	179,200	2,907	342	514	521	189	342	$559	163	.....	.....	$276
	Yuba, 3, B	555,000	11,074	1,878	1,741	2,545	1,994	1,218	268	199	.....	43	1,185
	Madera, 4, B	579,000	4,099	508	1,466	1,069	386	102	29	115	.....	100	325
Total		1,715,700	33,679	3,370	15,043	4,459	4,228	1,930	856	1,807	16	181	1,786
Cents per square yard-year		.....	1.96	.19	.88	.26	.25	.11	.05	.11	.....	.01	.10
Improvements	Mendocino, 1, C	402,500	978	.....	978	.....	.....	.....	.....	.....	.....	.....	.....
	Eldorado, 11, B	179,200	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Yuba, 3, B	555,000	12,961	4,016	6,914	456	500	212	790	58	.....	15	.....
	Madera, 4, B	579,000	433	168	260	3	1	.....	.....	.....	.....	1	.....
Total		1,715,700	14,372	4,184	8,152	459	501	212	790	58	.....	16	.....
Cents per square-yard-year		.....	.84	.24	.48	.03	.03	.01	.05	.....	.....	.....	.....

Symbols: PB, pavement base; PS, pavement surface; S, shoulders; CD, culverts and drains; GR, guard rail; G, grading; RS, roadside; T, trees; GE, general expense; Pat., patrolmen.

TABLE 19.—*Cost of 32.45 miles of oil-macadam pavement built by the State highway commission.*

	County, route, section.	Miles.	Width (feet).	Area (square yards).	Construction cost.	Cost per square yard.	Date completed.	Years under maintenance.	Square-yard-years.	Maintenance per square-yard-year (cents).	Improvement per square yard-year (cents).
Construction costs and costs of maintenance and improvements per square yard per year.	Mendocino, 1, C	7.73	15	68,024	$84,167	$1.237	June 23, 1914	5.92	402,500	3.9	0.9
	Eldorado, 11, B	5.27	12	37,101	102,020	2.750	July 31, 1915	4.83	179,200	1.6	.0
	Yuba, 3, B	9.45	15	83,160	72,644	.875	Sept. 24, 1913	8.67	555,000	2.0	2.3
	Madera, 4, b	10.00	15	88,000	73,832	.839	Oct. 29, 1913	6.58	579,000	.7	.1
Totals and averages		32.45	.....	276,285	332,663	1.206	.....	.....	1,715,700	1.96	0.84

TOTAL COSTS PER YEAR AND COSTS IN CENTS PER SQUARE YARD-YEAR, RESPECTIVELY.

		1914		1915		1916		1917		1918		1919		1920[1]		Totals per square yard.	
			Cents.		Cents.		Cents.		Cents.		Cents.		Cents.		Cents.		Cents.
Cost of improvements.	Mendocino, 1, C	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	$978	1.4	$978	1.4
	Eldorado, 11, B	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Yuba, 3, B	$1,015	1.2	$3,356	4.0	$2,889	3.5	.....	.....	.....	.....	$5,701	6.9	.....	.....	12,961	15.6
	Madera, 4, B	.....	.....	.....	.....	433	.5	.....	.....	.....	.....	.....	.....	.....	.....	433	.5
Totals and averages		1,015	.....	3,356	.....	3,322	.....	.....	.....	.....	.....	5,701	.....	978	.....	14,372	5.2
Cost of general maintenance.	Mendocino, 1, C	.....	.....	2,937	4.3	3,670	5.4	$1,301	1.9	$2,234	3.3	4,829	7.1	627	.9	15,599	22.9
	Eldorado, 11, B	.....	.....	256	.7	119	.03	293	.8	509	1.4	1,325	3.6	405	1.1	2,907	7.9
	Yuba, 3, B	967	1.2	864	1.0	1,068	1.3	890	1.1	985	1.2	3,689	4.4	2,611	3.1	11,074	13.3
	Madera	113	0.1	639	.7	1,153	1.3	222	.3	750	.9	804	.9	417	.5	4,099	4.7
Total		1,080	.....	4,696	.....	6,010	.....	2,706	.....	4,478	.....	10,647	.....	4,060	.....	33,679	12.2

[1] One-half year only.

PRESENT CONDITION OF CONSTRUCTED ROADS

To determine the present condition of the Portland cement concrete State highways and of pavement of other type incidentally laid field inspections were made of 1,734 miles of paved roads. These inspections were in such detail that each one-tenth mile of concrete could be classified; 7,500 photographs were taken and 638 sample concrete cores were drilled at intervals from the pavement. (In addition to the pavement inspected about 350 miles of graded State highways without paving were also inspected, with special reference to the features of grade and alignment.) All inspections were so organized that a thorough initial examination, with photographs, was first made, directed by such supervision as was found necessary. Then as fast as the data from those inspections developed, supplementary and more intensive studies were organized to cover portions of the pavement which presented unusual features or defects. Finally, a complete field inspection of the entire pavement, with photographic record and field notes in hand, was made as a check prior to the compilation of final figures.

All inspection field work and photographs were made with two main purposes in view: First, to determine the present condition of the highways with respect to

serviceability or usefulness to traffic, and, second, to determine the present physical condition of the pavement itself and the quality of the work done.

CLASSIFICATION.

To describe systematically the present physical condition of the concrete pavements, whether oiled or not, they were classified into six classes, designated by the letters A to F. It is particularly emphasized that with the exception of those sections of the pavement which contain failed portions, all of which are classed F, and also with some additional minor exceptions in the classes E and F, the classification by letter has no necessary relation to the present serviceability of the highways. Classes A to C, inclusive, are for practical purposes at present equally serviceable to traffic. Class D seldom presents bad travel conditions; class E includes some pavement which is rough to travel, and class F in several instances presented pavement very difficult to travel. It is to be noted, however, that where pavement is impaired to such an extent that repairs become necessary which result in fencing of considerable portions of the road against travel, then physical condition of the pavement becomes an impediment. Classes D, E, and F frequently require such repairs and reconstruction. The following definitions of the descriptive classes for cement concrete pavement were adopted:

A. A pavement in which the plainly visible transverse cracks do not exceed the normal number expected of a pavement constructed without expansion joints, and which has no plainly visible longitudinal cracks.

B. A pavement having more than the normal number of plainly visible transverse cracks, or with some "crowfoot" cracks at the edges, or with both.

C. A pavement similar to classes A and B and with one plainly visible longitudinal crack, or with a considerable number of "crowfoot" cracks.

D. A pavement so cracked transversely and longitudinally that numerous slabs are formed of less area than in class C, but that do not average less than about 50 square feet.

E. A pavement in which the plainly visible transverse and longitudinal cracks are so numerous that it is broken into slabs having areas less than about 50 square feet, but in which no general disintegration appears.

F. A pavement bady broken and with disintegrated portions.

The engineering inspection in the field determined by tenths of a mile, as measured by automobile odometer, to which of the above classes all concrete pavement belonged. This classification operation disregarded the presence or condition of the three-eighths-inch asphaltic oil surfacing, but sometimes where such oil surfacing was present, or particularly where it had been recently applied or renewed, the observation of cracks and other defects was made difficult, and for this reason 26.2 miles of concrete pavement with newly laid three-eighths-inch oil top was not classified, nor for similar reasons 50.39 miles of concrete "pavement-base" with 1½-inch Topeka or similar top. On sections with three-eighths-inch oil top an error in classification may be assumed to be one which tends to raise rather than lower the class. This is particularly true as between classes A to C, inclusive.

The record of this field inspection for classification is presented with explanatory legends in the "condition diagrams," which constitute Plates LXXIII to LXXXIV, inclusive, in Appendix H, and which are arranged according to the standard numbering system of the State Highway Commission for route, county, and section. The horizontal scale of these diagrams is two miles to the unit and the classification of the pavement by tenths of miles is schematically indicated by negative ordinates to an arbitrary vertical scale.

With reference to the descriptive classification of the 4-inch concrete pavement itself, it is to be noted that cracking is mainly the basis of measurement of classification and that practically all the pavement laid by the California State Highway Commission was without transverse joints. The classification required judgment in many instances to evaluate mixed classification within a tenth of a mile and also to evaluate unusual combinations of defects. It is not mathematically rigid and is subject to some small error of position in the sections due to differences in odometer calibrations. In the main it is correct in detail, and the totals are probably subject to very little error. For all other than concrete pavement such classification as excellent, good, fair, etc., only was made.

The results of the concrete pavement classification are summarized in Tables 20 and 21 and in Plates XV and XVI. In addition Table 22 presents a classification of concrete pavement and subgrade soil and Table 23 shows the mileage of all pavement and other roads constructed in the State highway system. There are also shown in Plates XVII to XXII, inclusive, a series of photographs of each class of concrete pavement above described.

PLATE XV.

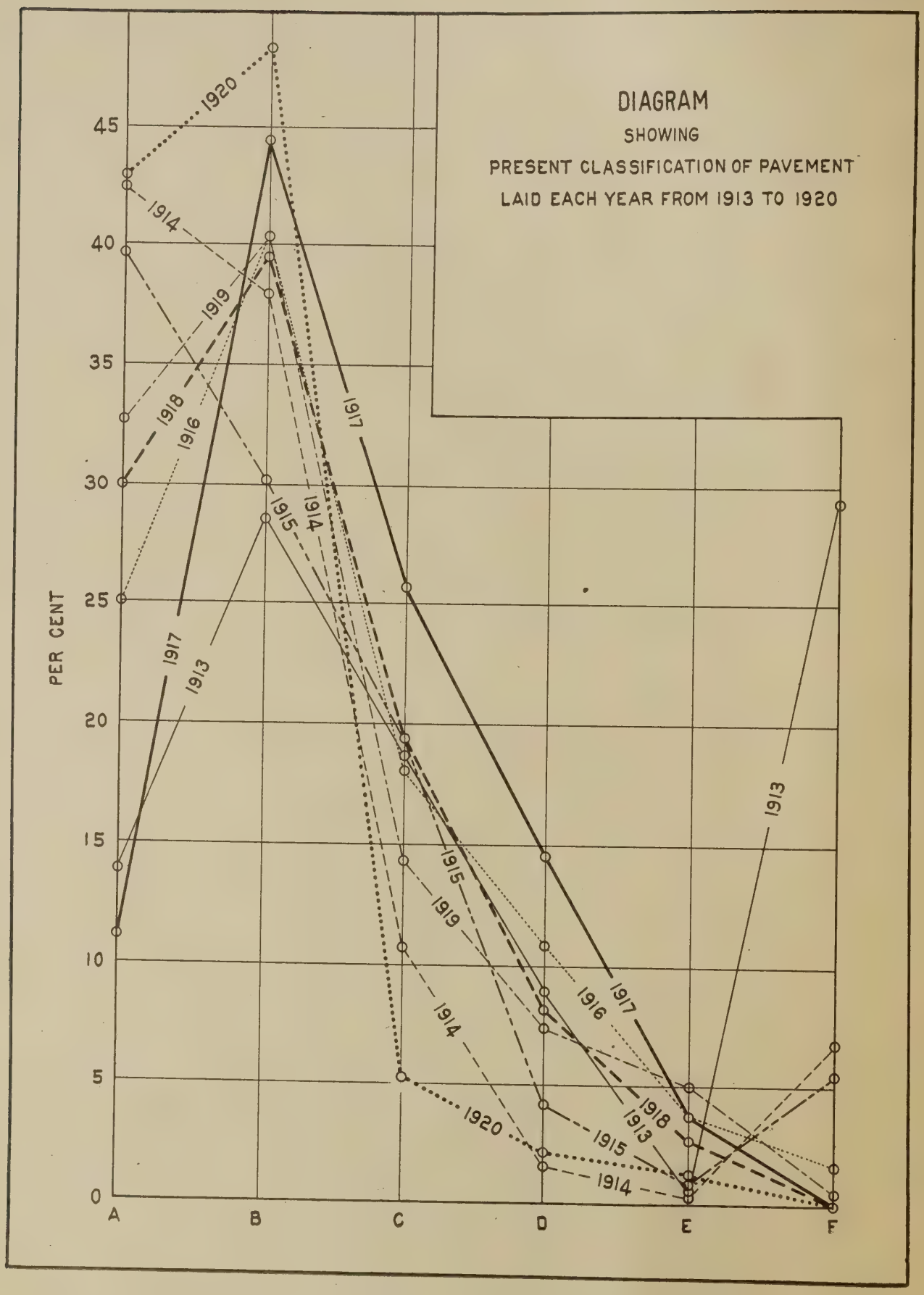


DIAGRAM
SHOWING
PRESENT CLASSIFICATION OF PAVEMENT
LAID EACH YEAR FROM 1913 TO 1920
PER CENT
45
40
35
30
25
20
15
10
5
0
A
B
C
D
E
F
1920
1914
1919
1918
1916
1917
1915
1913

PLATE XVI.

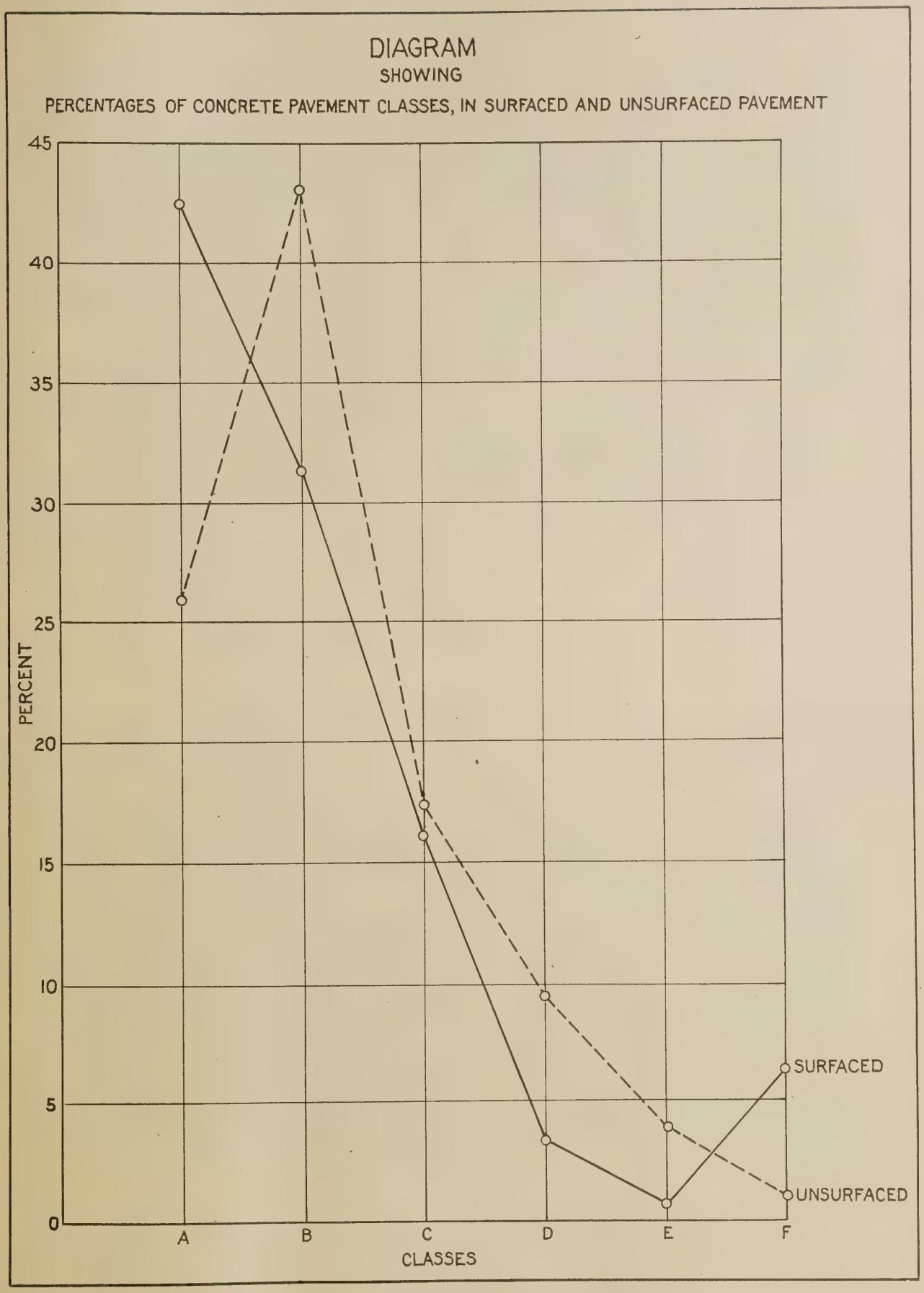


DIAGRAM
SHOWING
PERCENTAGES OF CONCRETE PAVEMENT CLASSES, IN SURFACED AND UNSURFACED PAVEMENT
45
40
35
30
25
20
15
10
5
0
PERCENT
A
B
C
D
E
F
CLASSES
SURFACED
UNSURFACED

TABLE 20.—*Showing the classified condition of concrete pavement built each year by the State Highway Commission.*

Class.	CONCRETE WITH ⅜-INCH OIL TOP. Years constructed. 1913	1914	1915	1916	1917	1918	1919	1920	Totals.	Class.	UNSURFACED CONCRETE. Years constructed. 1913	1914	1915	1916	1917	1918	1919	1920	Totals.
	Miles.	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*		*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
A	2. 83	71. 35	135. 59	26. 90	2. 87	0. 27	0. 04	.....	239. 85	A	.....	.....	3. 74	46. 48	3. 78	37. 27	53. 87	33. 24	178. 38
B	5. 83	63. 75	89. 44	15. 19	1. 79	. 63	.....	.....	176. 65	B	.....	.....	16 91	104 43	24. 50	48. 87	66. 78	37. 32	298. 81
C	3. 85	18 27	60. 19	6. 49	2. 81	.....	.....	.....	91. 61	C	.....	.....	7. 98	46. 92	12. 47	24. 37	23 90	4. 15	119. 79
D	1. 83	2. 67	11. 40	1. 75	1. 50	.....	.....	.....	19. 15	D	.....	.....	3. 25	30. 84	7. 16	10. 24	12. 20	1. 60	65. 29
E	. 10	. 40	2. 40	. 35	. 10	.....	.....	.....	3. 35	E	.....	.....	. 75	11. 20	2. 19	3. 29	8. 23	1. 00	26. 66
F	6. 00	11. 50	19. 04	.....	.....	.....	.....	.....	[1] 36. 54	F	.....	.....	. 10	5. 13	.....	. 05	. 25	. 10	5. 63
Total.	20. 46	167. 94	318. 06	50. 68	9. 07	. 90	. 04	.....	[2] 567. 15	Total.	.....	.....	32. 73	245. 00	50. 10	124. 09	165. 23	77. 41	[2] 694. 56

[1] This total includes 17.75 miles of new Topeka on concrete pavement classified as failed.
[2] There were 26.20 miles additional of ⅜-inch oil-top concrete which, on account of new surface, could not be classified; 2.7 miles laid in 1915, and 23.5 miles laid in 1916. There were also 26.56 miles of additional unsurfaced concrete pavement that was inaccessible and not classified; 6.99 miles built in 1916, 0.44 in 1919, and 19.13 in 1920. In addition to these unclassified items is a total of 50.39 miles of unclassified concrete on which 1½-inch Topeka and some Willite has been laid.

TABLE 21.—*Showing all classified concrete pavement built by the State, surfaced and unsurfaced combined.*

Year built. Class.	1913 Miles.	1913 Per cent.	1914 Miles.	1914 Per cent.	1915 Miles.	1915 Per cent.	1916 Miles.	1916 Per cent.	1917 Miles.	1917 Per cent.	1918 Miles.	1918 Per cent.	1919 Miles.	1919 Per cent.	1920 Miles.	1920 Per cent.	Totals. Miles.	Totals. Per cent.
A	2. 83	13. 8	71. 35	42. 5	139. 33	39. 7	73. 38	24. 8	6. 65	11. 3	37. 54	30. 0	53. 91	32. 6	33. 24	42. 9	418. 23	33. 1
B	5. 85	28. 6	63. 75	38. 0	106. 35	30. 3	119. 62	40. 5	26. 29	44. 4	49. 50	39. 6	66. 78	40. 4	37. 32	48. 2	475. 46	37. 3
C	3. 85	18. 8	18. 27	10. 9	68. 17	19. 4	53. 41	18. 1	15. 28	25. 8	24. 37	19. 5	23. 90	14. 4	4. 15	5. 4	211. 40	16. 7
D	1. 83	9. 0	2. 67	1. 6	14. 65	4. 2	32. 59	11. 0	8. 66	14. 6	10. 24	8. 2	12. 20	7. 4	1. 60	2. 1	84. 44	6. 7
E	. 10	. 5	. 40	. 2	3. 15	. 9	11. 55	3. 9	2. 29	3. 9	3. 29	26. 6	8. 23	5. 0	1. 00	1. 3	30. 01	2. 4
F	6. 00	29. 3	11. 50	6. 8	19. 14	5. 5	5. 13	1. 7	.....	.....	. 05	. 4	. 25	. 2	. 10	. 1	42. 17	3. 4
Total	20. 46	100	167. 94	100	350. 79	100	295. 68	100	59. 17	100	124. 99	100	165. 27	100	77. 41	100	1,261. 71	100
Per cent of total each year	1. 7		13. 3		27. 8		23. 4		4. 7		9. 9;;		13. 1		6. 1		100	

TABLE 22.—*Concrete pavement classes and underlying soil types.*

Classes	Miles in each class. A.	B.	C.	D.	E.	F.	Total	Total percentage in classes D, E. and F.
Soil type:								
1. Clay and adobe soils (includes clay, silty clay, clay-loam, and clay)	131. 9	225. 7	116. 1	58. 2	24. 2	27. 5	583. 6	18. 9
2. Marsh lands (includes salt marsh and peat lands)	. 3	. 9	. 2	. 1	. 0	. 0	1. 5	. 0
3. Loams (includes loam, clay-loam, silt-loam, and silty clay loam)	89. 5	104. 9	56. 0	11. 5	2. 0	9. 0	272. 9	8. 2
4. Sandy loam (includes coarse sandy loam, sandy loam, and fine sandy loam)	156. 8	124. 1	38. 1	11. 7	1. 6	5. 5	337. 8	5. 6
5. Sand, and sand and gravel	53. 2	34. 8	8. 5	3. 1	2. 3	. 2	102. 1	5. 5
Total	431. 7	49. 04	218. 9	84. 6	30. 1	42. 2	[1] 1,297. 9	12. 1

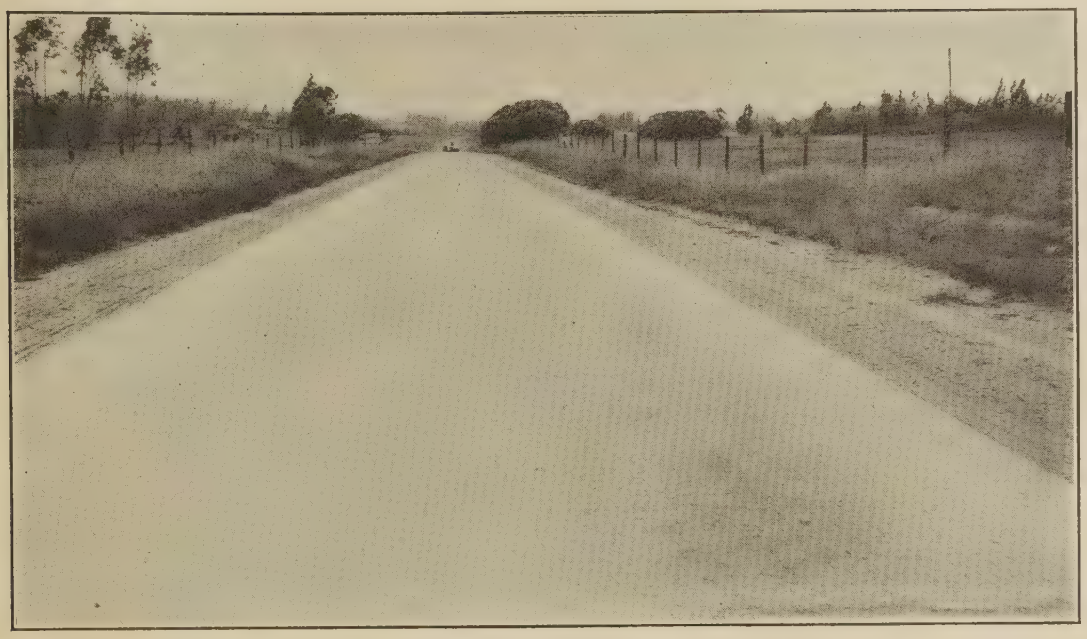
[1] Includes 36.2 miles built by counties.

TABLE 23.—*Showing all roads constructed and under construction in the California State system, by types and by years, completed.*[1]

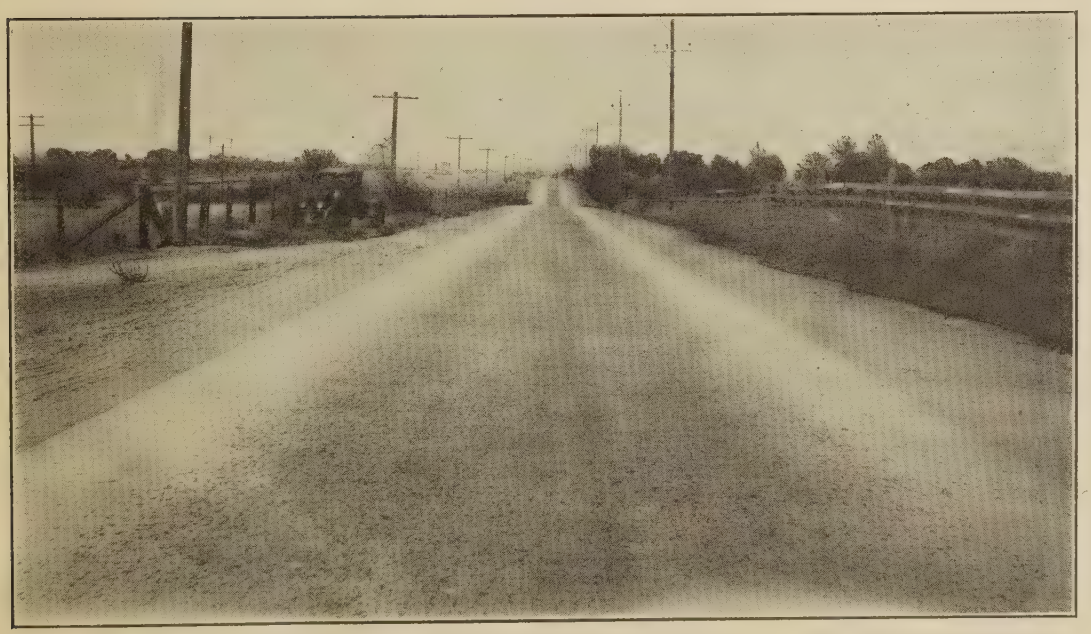
	1913	1914	1915	1916	1917	1918	1919	1920	Total.
Laid by California State Highway Commission:	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*	*Miles.*
Concrete with ⅜-inch oil top	20. 46	167. 94	318. 06	50. 68	9. 07	0. 90	0. 04	.....	567. 15
Concrete unsurfaced	.....	.....	32. 73	245. 00	50. 10	124. 09	165. 23	79. 41	694. 56
Concrete, unclassified, surfaced with 1½-inch bituminous surface	11. 15	20. 33	7. 74	2. 09	3. 44	4. 24	.....	1. 40	[2] 50. 39
Concrete, unsurfaced, not classified	.....	.....	.....	6. 99	.....	.....	. 44	19. 13	[3] 26. 56
Concrete, ⅜-inch surface, not classified	.....	.....	2. 70	23. 50	.....	.....	.....	.....	26. 20
Total	31. 61	188. 27	361. 23	328. 26	62. 61	129. 23	165. 71	97. 94	1,364. 86
Concrete base under construction	.....	.....	.....	.....	.....	.....	.....	.....	140. 05
Oil macadam	19. 04	7. 64	8. 22	7. 36	.....	8. 27	4. 91	.....	[4] 55. 44
1½-inch bituminous surface on macadam base	.....	16. 37	. 31	.....	. 07	.....	.....	. 91	17. 66
Total paving of all kinds built by California Highway Commission	50. 65	212. 28	369. 76	335. 62	62. 68	137. 50	170. 62	98. 85	1,578. 01
Graded but not paved	.....	.....	.....	.....	.....	.....	.....	.....	377. 10
Grading under construction	.....	.....	.....	.....	.....	.....	.....	.....	319. 40
Total mileage, State construction	.....	.....	.....	.....	.....	.....	.....	.....	2, 274. 51
Laid by counties and incorporated in State system:									
Concrete, with ⅜-inch oil top	.....	.....	.....	.....	.....	.....	.....	.....	22. 81
Concrete, with 1½-inch bituminous surface	.....	.....	.....	.....	.....	.....	.....	.....	1. 01
Concrete, unsurfaced	.....	.....	.....	.....	.....	.....	.....	.....	13. 58
Oil macadam	.....	.....	.....	.....	.....	.....	.....	.....	171. 15
Asphaltic concrete	.....	.....	.....	.....	.....	.....	.....	.....	16. 54
Total mileage, county construction	.....	.....	.....	.....	.....	.....	.....	.....	225. 09
Grand total, improved roads in system	.....	.....	.....	.....	.....	.....	.....	.....	2, 499. 60

[1] Approximately as of Sept. 15, 1920.
[2] 17.75 miles of 1½-inch Topeka or concrete which was classed F is included, but appears elsewhere under concrete surface with ⅜-inch oil top.
[3] This total includes 9.26 miles of "double-decked" or second-story concrete.
[4] 15.22 miles resurfaced only; base built by county.

PLATE XVII.



CLASS A PAVEMENT. 1 SONOMA C.



CLASS A PAVEMENT. 17 PLACER A.

PLATE XVIII.

CLASS B PAVEMENT. 7 SOLANO D.

CLASS B PAVEMENT. 4 LOS ANGELES A.

PLATE XIX.

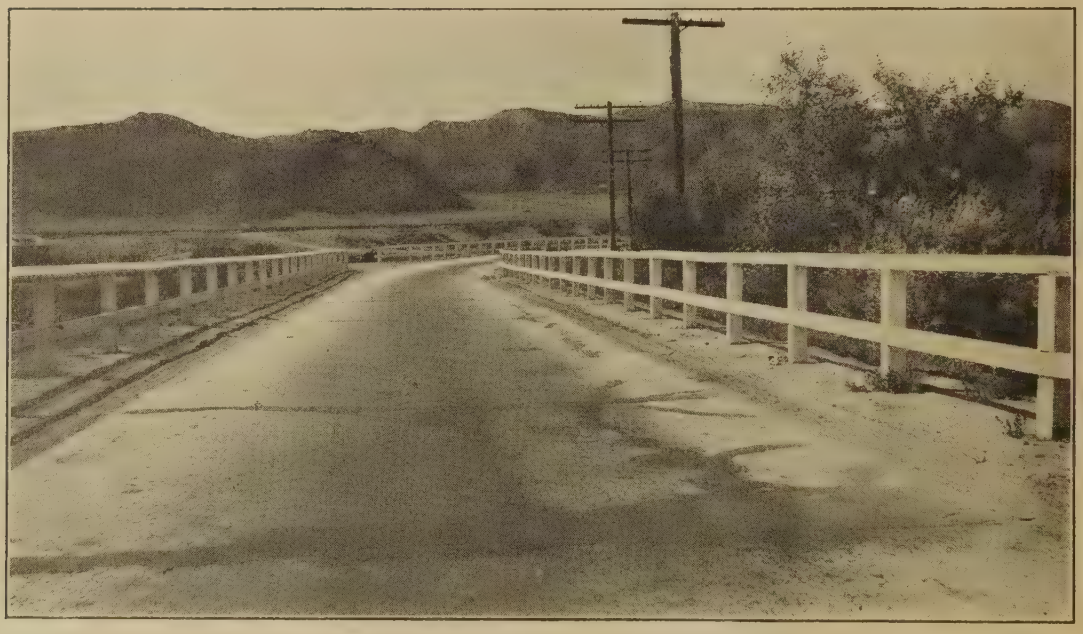
CLASS C PAVEMENT. 7 SOLANO A.

CLASS C PAVEMENT. 5 ALAMEDA A. OIL TOP

75712—22——5

PLATE XX.

CLASS D PAVEMENT. 8 SOLANO A.



CLASS D PAVEMENT. 4 LOS ANGELES A.

PLATE XXI.

CLASS E PAVEMENT. 7 SOLANO D.

CLASS E PAVEMENT. 4 KERN C.

PLATE XXII.

CLASS F PAVEMENT. 15 COLUSA A. OIL TOP.

CLASS F PAVEMENT. 2 VENTURA B. OIL TOP.

PHOTOGRAPHS.

Photographs at standard intervals of from one-tenth to five-tenths of a mile were taken throughout the inspection. Supplementary close-up pictures of special features or defects were also taken.

The photographs supported the field classifications and checked in general with the notes, but also tended to indicate a higher class than existed, particularly where oil surfacing was present. On the other hand, the photographs, by foreshortening, tended in exceptional cases to indicate as class B some pavement that belonged to class A. All such cases were carefully rechecked in the field but the oil-surface concrete is still probably classed somewhat too high and consequently the diagram of Plate XVI must be interpreted with this in mind. The photographs arranged by routes are filed in the Bureau of Public Roads.

CRACKS IN ADOBE SOIL. 3 BUTTE D.

SUBGRADE SOIL.

Supplementing inspection of the pavement an inspection and classification of the underlying soil was simultaneously made and subsequently checked in the field by soil experts from the Bureau of Soils and the division of farm irrigation investigations of the Bureau of Public Roads, all in the Department of Agriculture. The soil classification was further checked by soil maps and other published and unpublished information available in the Department of Agriculture or at the University of California. This soil classification also is indicated symbolically on the condition diagrams in accordance with the legends there shown.

In addition to the soil classification reported by the engineers in the field, a supplementary determination of the class of soil was made from several hundred samples of soil taken at those points on the different routes where it was deemed desirable to take sample cores of the pavement itself.

Such soil samples were taken to indicate the soil and the subsoil to a depth of 6 feet, and these samples were classified by experts of the Bureau of Soils; results from the classification of these samples were given precedence in any apparent conflict of soil classification.

For those special portions of the pavement where intensive study was found desirable to determine the cause and nature of failure of pavement, additional soil samples were taken in considerable numbers and were examined in the laboratory of the University of California for moisture content and moisture equivalent, and the results are described in the reports on the special defective sections below.

SOIL CLASSIFICATION.

The classifications of the subgrade soil used and shown symbolically on the condition diagrams of Appendix H are as follows:

1. Clay and adobe soils (includes clay, silty clay, clay-loam and clay).
2. Marsh lands (includes salt marsh and peat lands).
3. Loams (includes loam, clay-loam, silt-loam, and silty clay loam).
4. Sandy loam (includes coarse sandy loam and fine sandy loam).
5. Sand, and sand and gravel.

In connection with the photographic exhibits accompanying this report are shown photographs of the laboratory experimental tests for shrinkage of various samples of soil of the above classes.

SPECIAL STUDIES OF DEFECTIVE PAVEMENT.

To investigate particular causes of failure on 12 sections of the State highway, where classification showed a large percentage of classes D to F, special intensive studies were made over periods of from 3 to 14 days by six senior highway engineers of the Bureau of Public Roads.

In each case the interval of construction, the name of the contractor and resident engineer, the nature and source of materials, the available reports of State inspectors, weather and other details surrounding the work were carefully determined. The test results of materials used were also investigated together with the reports of tests of concrete made by the laboratory of the State Highway Commission, and the tests of concrete cores drilled from the pavement. Extensive investigations of drainage conditions on the ground and in the vicinity were also made, local people were interviewed, and a special effort was made to determine alkali conditions and the source of mixing and curing water for all concrete.

As a result of these 12 special studies there are reports in great detail on file in the Bureau of Public Roads. These reports show varying primary and secondary causes of failure. Among these causes subsoil and drainage conditions, particularly on new locations, predominate and poor and thin concrete follows. One failure is apparently due to construction of concrete pavement in the cool fall, winter, and early spring seasons followed by the high temperature of July in the interior valley. Several reports raise the question of alkali in the mixing or ponding water or in the moist subgrade and particularly in basin or flat valley areas. Other contributory causes are dirty sand and poor curing, lax inspection of mix, rough finish and impact of heavy truck traffic and combinations of two or more of the above causes. The State repair trucks overloaded with material have greatly contributed to the completion of failure during repairs on parts of the same or near-by sections.

A special effort was made to determine the nature of the subgrade soil and its moisture content. All of these investigations were carried on between the middle of September and the first of November and the soil studies were made largely in September and early in October at the end of the dry season. It is to be noted that the season of 1920 was unusually dry and that previous seasons also had been noticeably dry ones.

The soil investigations required borings to be made at intervals across the entire section of the roadway and to a depth of about 6 feet. From six to eight such borings were made in each instance on 35 sections. They were made with a 2-inch soil auger in the center of the pavement and at the edges and through the embankment in fill and in the ditch line in certain instances. The samples which were brought up from the various depths were immediately placed in tightly sealed tin cans and shipped to the soil laboratory of the University of California. In all 1,207 such samples were taken.

ALKALI CRUST ON ADOBE SOIL. 7 GLENN A.

In the laboratory three principal tests were made on the soils:

(*a*) Soil moisture determination.
(*b*) Moisture equivalent determination.
(*c*) Contraction or shrinkage measurement.

SOIL MOISTURE DETERMINATIONS.

The contents of each can were thoroughly mixed and reduced by rolling about 10 times on a sheet of celluloid and duplicate 100-gram samples weighed into aluminum

dishes 2 inches in diameter and one-half inch in depth. Moister soils were kneaded to a round mass. The filled dishes were weighed and placed in an electric oven for five hours or more (and all night in case of heavy soils), and all at a temperature of about 100° C. They were then cooled in a calcium-chloride dessicator and again weighed. The percentage was then calculated as the ratio (in hundredths) of the difference between the first two weighings (of wet and dry soil and dish) divided by the net weight of the dry soil. In all there were 1,428 such moisture determinations.

MOISTURE EQUIVALENT DETERMINATIONS.[10]

To develop a comparative basis for degree of saturation of soils, moisture equivalent determinations were made on 150 type samples. The method of Briggs and Schauntz was used and consisted essentially in determining the amount of moisture that a sample can hold against a force of one thousand times gravity developed by centrifugal force. The contents of each can were air-dried, reduced by rolling, and sifted. The centrifuge used to drive off moisture held 16 sample cups and 8 samples in duplicate were run simultaneously. Two wetted check samples were placed in cups directly opposite in the machine, which was revolved at a speed of 2,400 revolutions per minute for 30 minutes. Then the samples were quickly removed to tightly covered cans and weighed at once. The can lids were then removed and the sample dried over night at 100° C. The cans were then covered and when cooled were again weighed. The percentage of moisture in the sample was determined as the quotient of the loss by drying after removal from the centrifuge and the weight of the dry soil.

SHRINKAGE TESTS.

One hundred and forty shrinkage tests were run on the soil samples in order to determine the per cent of shrinkage under standard conditions. The soils varied from light sand to heavy adobe, and consequently contraction varied greatly. Typical samples were dried and sifted and then wetted to about capillary saturation and kneaded and placed in aluminum cups to dry. The wet soil was struck level and allowed to dry in room temperature four days. The volume of each soil cake was then determined by mercury displacement and compared with the volume of the cup. The volume of the dried soil was expressed as a percentage of the wet volume or of the volume of the cup.

Exact details of each process of all of the above tests are on file in the Bureau of Public Roads. In the shrinkage tests water was first tried instead of mercury, but it was found necessary to waterproof the cakes with sprayed shellac. The volume of this shellac coating was negligible but the coating was not perfectly waterproof and air clung to the inside of the cup and cakes and prevented an accurate reading before water could penetrate the shellac, consequently mercury was substituted. There was some difficulty with the mercury on account of its tendency to accumulate dirt and oxidize at the surface which required wiping the mercury surface with chamois after each run.

Table 24 shows the percentage of shrinkage, moisture equivalent and moisture content of typical subgrade soils and Plates XXIII to XXVI, inclusive, are corresponding pictures showing shrinkage.

SUBSOIL MOISTURE CROSS SECTIONS.

In Appendix D, plates LIX to LXIV, inclusive, are given 9 cross sections of the State highway showing lines of equal moisture content as determined by the moisture content test described above. These sections are selected as representative of the 35 reported and indicate in a general way the loss of moisture in the different parts of the section. In some cases the nature of the soil is shown on the section. The general nature of the soil in each case is also indicated on the "Condition diagram" for the corresponding section (Plates LXXIII to LXXXIV, inclusive, Appendix H). These moisture content sections are presented as indicative of a condition which probably operates to cause unequal bearing power across the section of the pavement. The samples were nearly all taken before any rains fell in the fall of 1920 and after a very dry summer. The cross sections clearly show that, on heavy soil, moisture remains directly below the center of the pavement indefinitely and leaves the pavement at the edges with resultant shrinkage and change in bearing power.

BEARING POWER.

Soil studies begun in the laboratory of the Bureau of Public Roads at Washington have resulted in preliminary and tentative tests for studying the bearing power of soils.

The tests consist essentially in subjecting previously prepared samples of the soil containing various percentages of moisture to uniformly increasing loads applied through a bearing block 10 square inches in area and measuring the corresponding penetration.

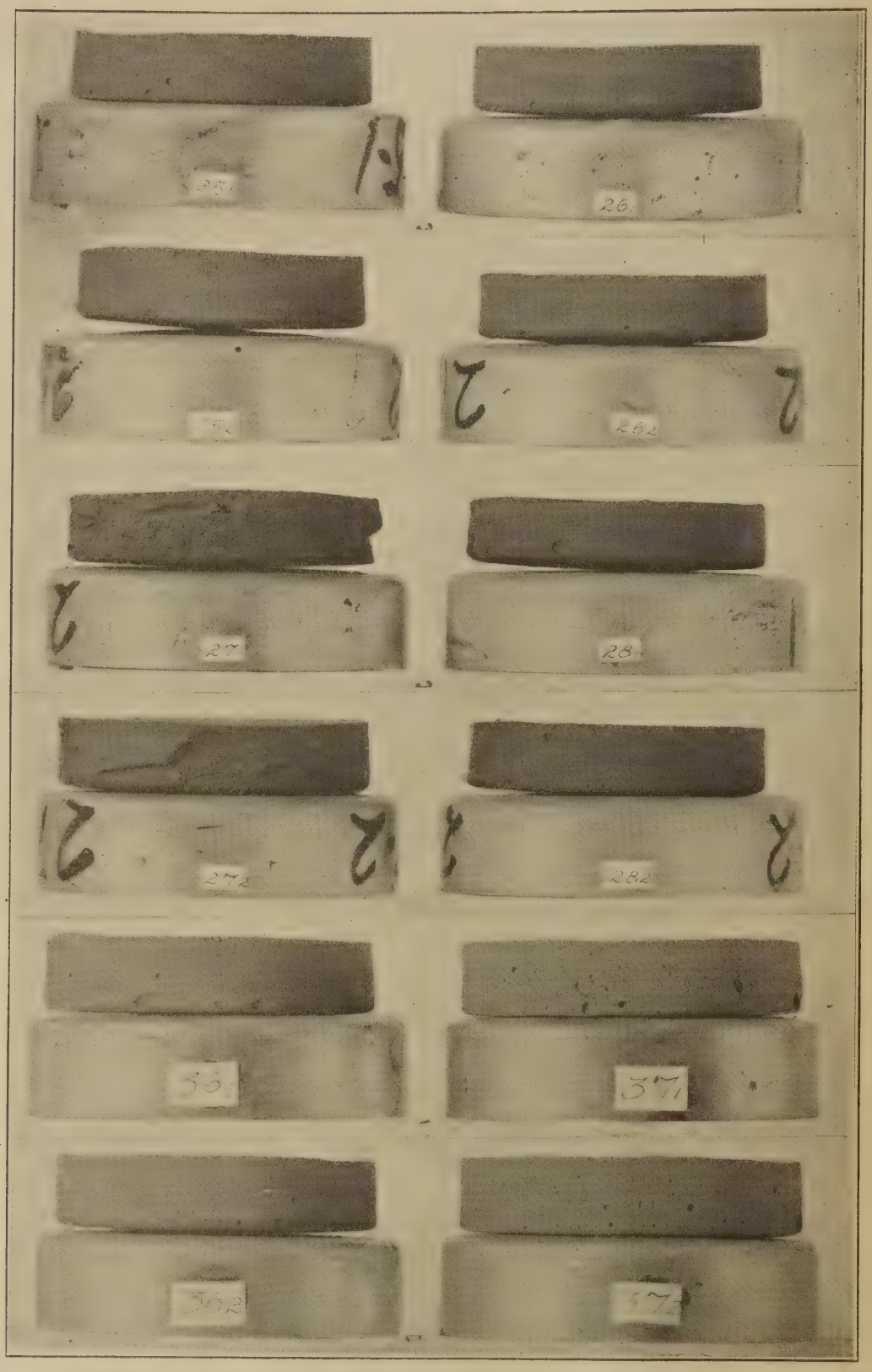
For two samples of soil with varying moisture content, results are shown in Plates XXVII and XXVIII.[11]

Since a soil is characterized by its moisture equivalent, when the moisture content exceeds the moisture equivalent it contains sufficient free water to considerably reduce the bearing power, therefore, the moisture equivalent percentage is a critical percentage in respect to bearing power.

[10] See reprint from proceedings of American Society of Agronomy, volume 2, 1920, "Moisture Equivalent Determinations and their Application," by Lyman J. Briggs and J. W. McLane.

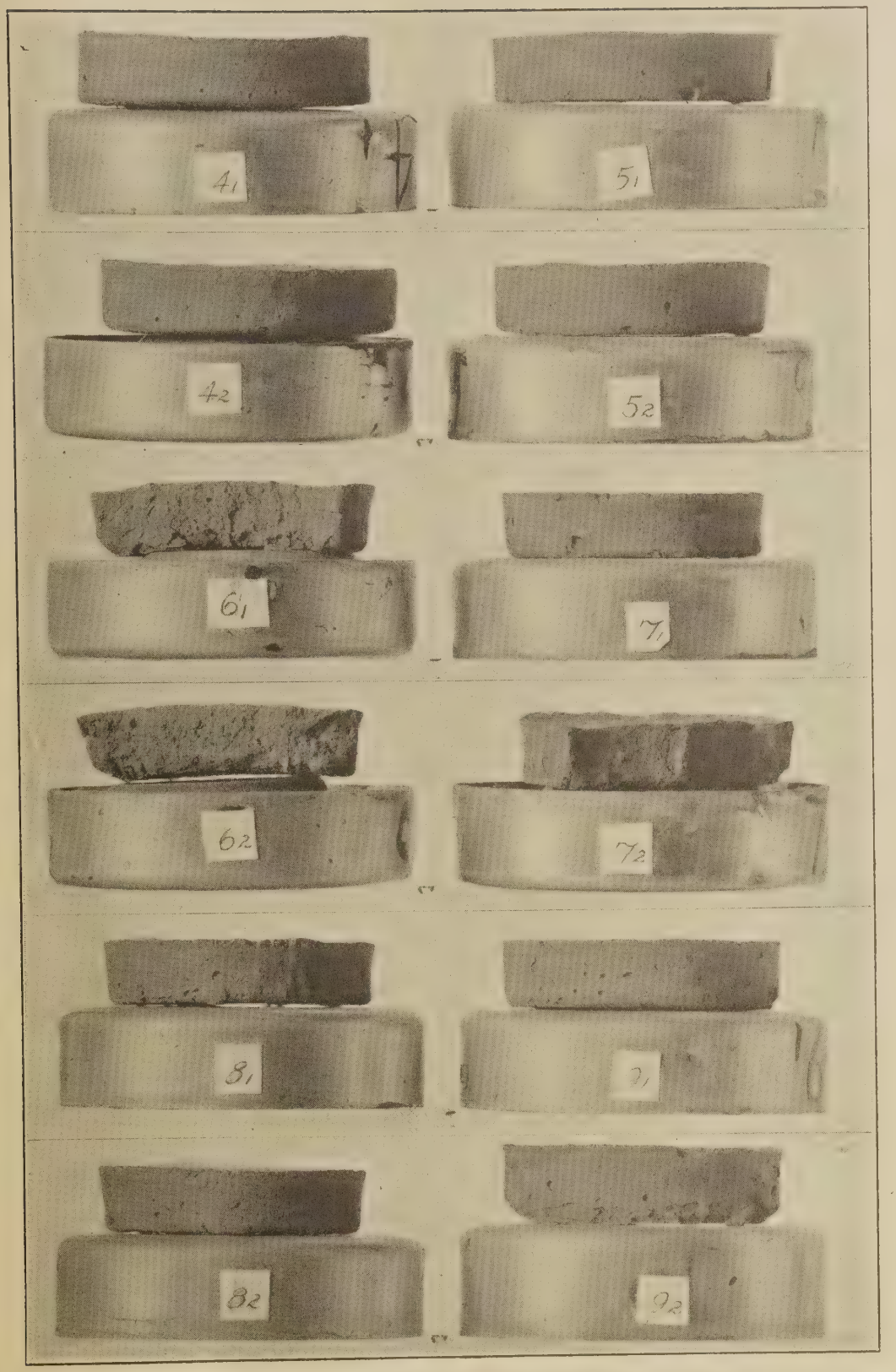
[11] These are advanced studies from work now under way.

PLATE XXIII.



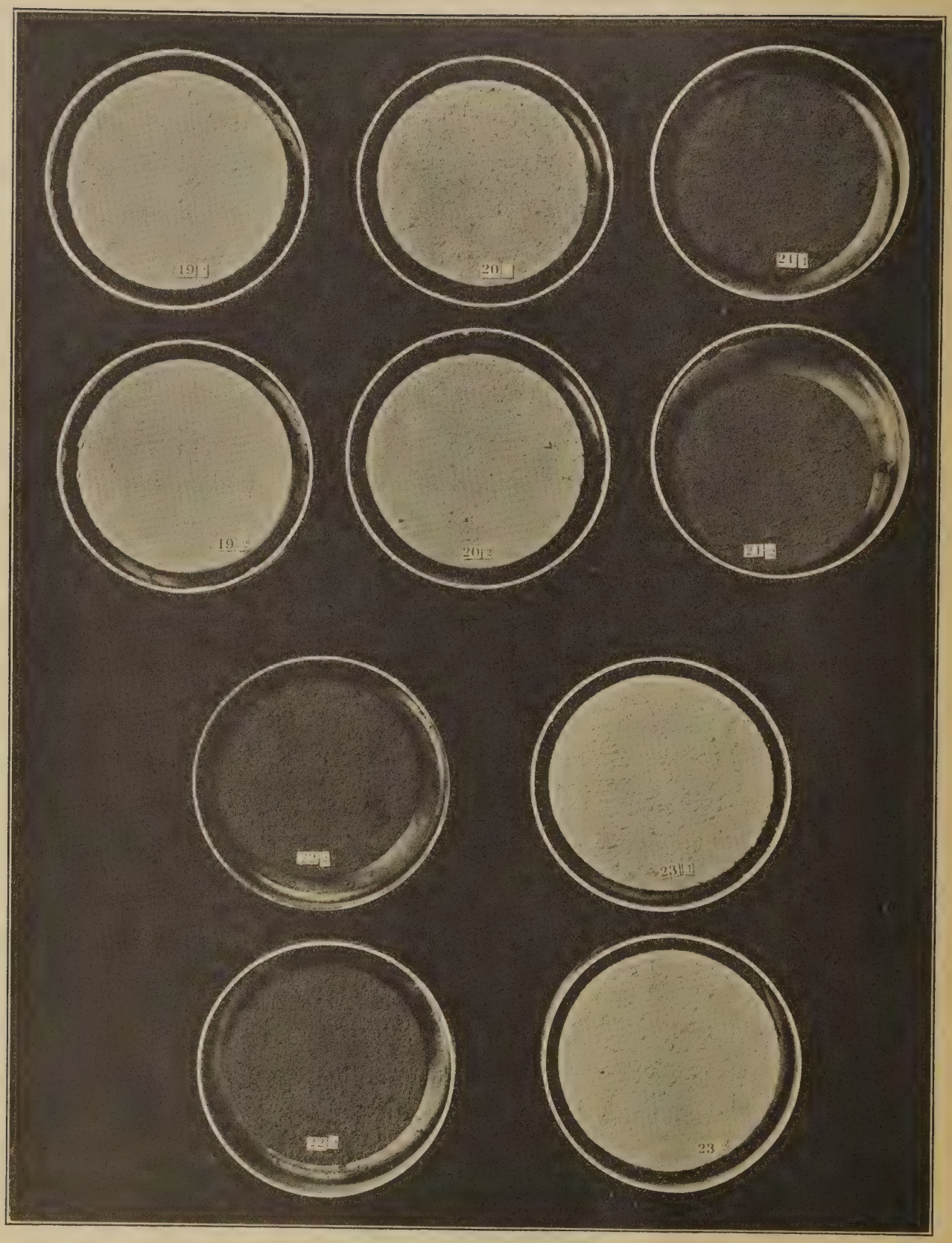
PROFILE VIEWS OF SOIL SHRINKAGE. SAMPLES FROM 2 LOS ANGELES B.

PLATE XXIV.



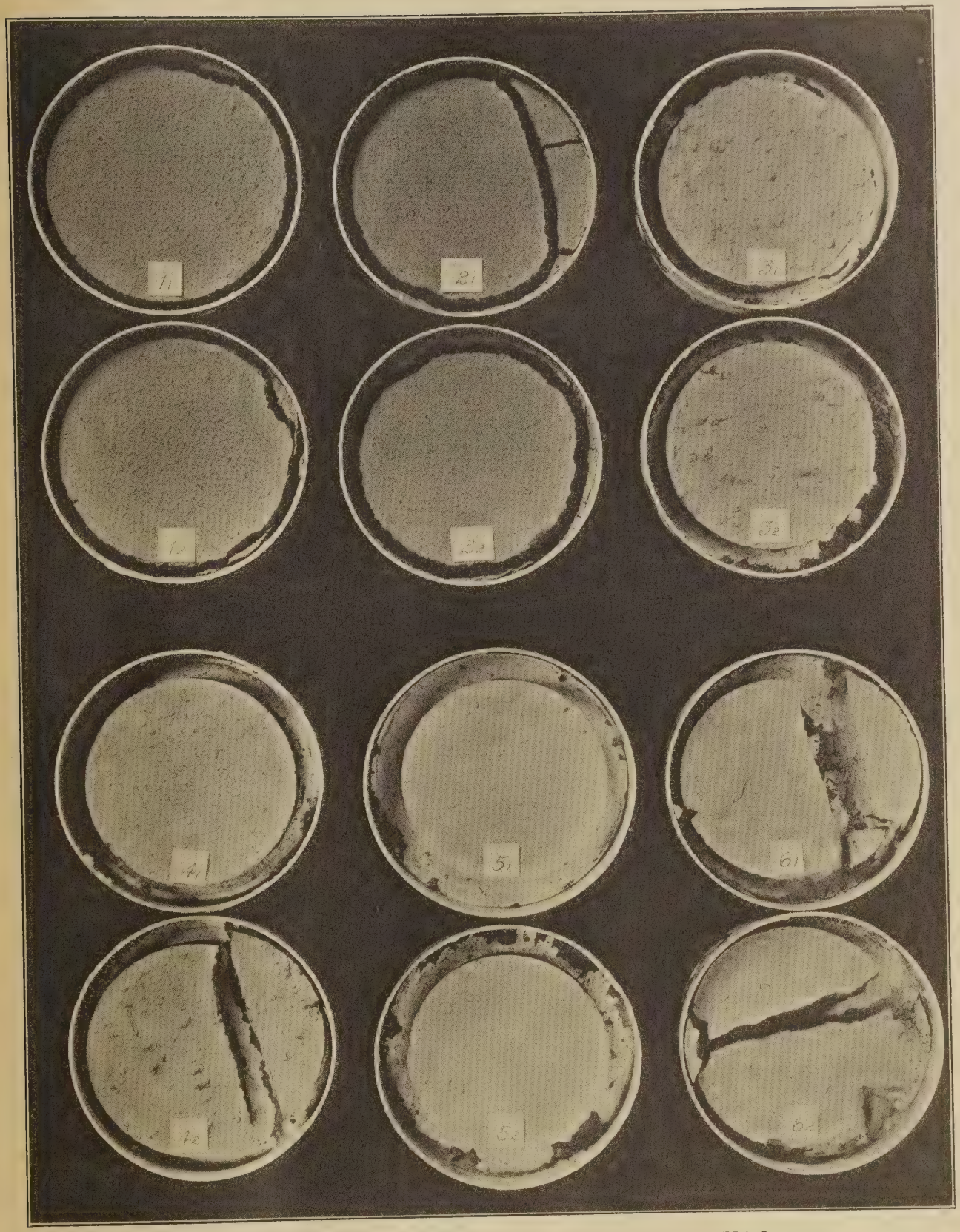
PROFILE VIEWS OF SOIL SHRINKAGE. SAMPLES FROM 5 ALAMEDA B.

PLATE XXV.



TOP VIEWS OF SOIL SHRINKAGE. SOIL SAMPLES FROM 1 SONOMA C.

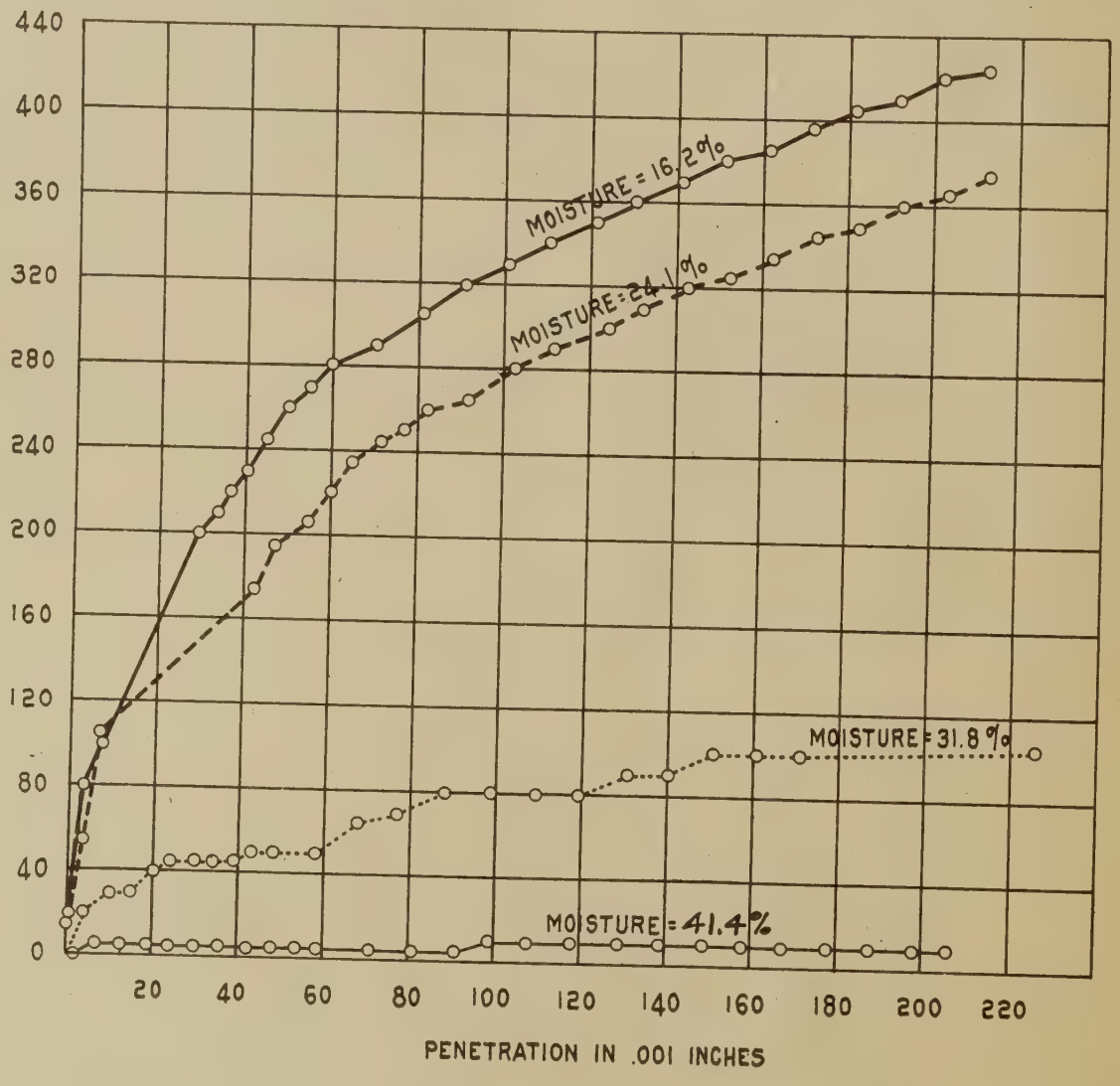
PLATE XXVI.



TOP VIEWS OF SOIL SHRINKAGE. SOIL SAMPLES FROM 5 ALAMEDA B.

PLATE XXVII.

CURVES SHOWING RELATION BETWEEN MOISTURE CONTENT
AND
BEARING POWER OF SOIL #16807

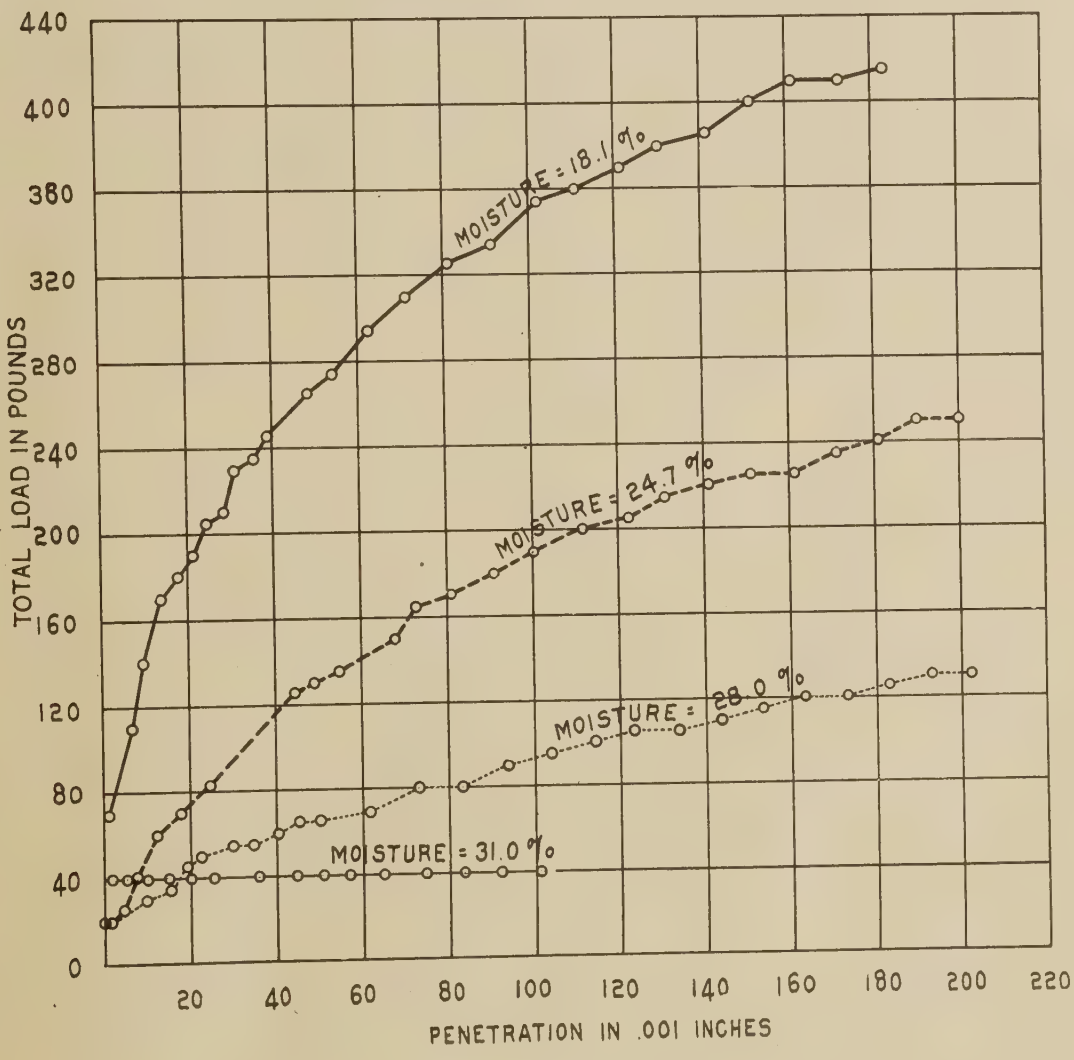


MOISTURE EQUIVALENT NOT AVAILABLE

SAMPLE FROM COLUSA 7-C 8.1 MILES NORTH OF COLUSA JUNCTION

PLATE XXVIII.

CURVES SHOWING RELATION BETWEEN MOISTURE CONTENT
AND
BEARING POWER OF SOIL # 17227



SAMPLE FROM LOS ANGELES 2-B
MOISTURE EQUIVALENT = 24.0 %
MOISTURE CONTENT OF ADJACENT SAMPLES IN PLACE ABOUT 21.5 %

TABLE 24.—*Showing percentage of shrinkage, moisture equivalent, and moisture content of subgrade soils.*

Location and position.				Photograph No.	Shrinkage per centage of original wet volume after drying.	Moisture equivalent (per cent).	Moisture content (per cent).
County.	Route, section.	Mile or station.	Depth of sample (feet).				
		Mile.					
Kern	4-F	3.7	0- 1.5	1	80.82	19.95	14.0
Do	4-F	3.7	1.5- 3.0	2	83.99	19.55	13.57
Do	4-F	4.0	0- 1.5	3	69.1	22.5	13.55
Do	4-F	4.0	1.5- 3.0	4	63.25	29.4	15.8
Do	4-F	4.6	0- 1.5	5	74.78	18.12	9.21
Do	4-F	4.6	1.5- 3.0	6	80.51	15.7	5.71
Do	4-F	5.1	0- 1.5	7	75.96	16.0	8.61
Do	4-F	5.1	1.5- 3.0	8	76.19	18.8	10.82
Do	4-B	2.3	0- 1.5	9	79.63	20.5	14.73
Do	4-B	2.3	1.5- 3.0	10	70.85	23.15	16.3
Do	4-B	2.7	0- 1.5	11	84.89	14.92	11.65
Do	4-B	2.7	1.5- 3.0	12	79.76	18.67	14.0
Do	4-B	1.7	3.0- 4.5	13	93.05	12.22	11.16
Do	4-B	3.2	0- 1.5	.....	.....	5.35	4.01
Do	4-B	3.2	1.5- 3.0	.....	.....	5.78	4.47
		Station.					
Sonoma	1-C	238	0- 1.5	14	42.89	40.6	32.15
Do	1-C	238	1.5- 3.0	15	60.66	42.7	50.7
Do	1-C	238	3.0- 4.5	.....	.....	25.3	24.9
Do	1-C	238	4.5- 6.0	16	82.17	21.9	24.2
Do	1-C	284	0- 1.5	17	46.02	41.2	36.5
Do	1-C	284	1.5- 3.0	18	42.05	43.3	29.6
Do	1-C	284	3.0- 4.5	19	62.29	32.3	30.4
Do	1-C	284	4.5- 6.0	20	59.94	32.0	29.0
Do	1-C	319	0- 1.5	21	46.66	33.7	23.6
Do	1-C	319	1.5- 3.0	22	51.84	33.3	29.4
Do	1-C	319	3.0- 4.5	23	66.7	28.2	26.65
Do	1-C	319	4.5- 6.0	.....	60.05	31.25	28.9
		Mile.					
Los Angeles	2-B	12.2	0- 1.5	19	55.67	27.7	16.13
Do	2-B	12.2	1.5- 3.0	20	56.56	28.89	14.82
Do	2-B	12.2	3.0- 4.5	21	51.36	30.47	13.93
Do	2-B	12.2	4.5- 6.0	22	52.58	31.67	15.28
Do	2-B	13.2	0- 1.5	23	53.83	27.63	22.16
Do	2-B	13.2	1.5- 3.0	24	46.11	33.1	20.15
Do	2-B	13.2	3.0- 4.5	25	50.14	30.91	17.13
Do	2-B	13.2	4.5- 6.0	26	49.41	29.19	17.2
Do	2-B	15.0	0- 1.5	27	60.42	24.21	21.52
Do	2-B	15.0	1.5- 3.0	28	53.03	28.52	19.35
Do	2-B	15.0	3.0- 4.5	29	55.54	27.99	18.52
Do	2-B	15.0	4.5- 6.0	30	57.88	26.81	16.46
Do	2-B	15.5	0- 1.5	34	60.76	26.3	19.2
Do	2-B	15.5	1.5- 3.0	35	66.03	24.4	18.4
Do	2-B	15.5	3.0- 4.5	36	63.01	23.95	18.75
Do	2-B	15.5	4.5- 6.0	37	70.28	20.5	14.95
Do	2-B	26.5	0- 1.5	38	72.08	23.7	17.2
		Station.					
Humboldt	1-G	323	0- 1.2	24	65.65	25.8	22.9
Do	1-G	323	1.5- 3.0	25	66.54	24.7	25.1
Do	1-G	323	3.0- 4.5	33	66.08	30.0	28.8
Do	1-G	413	0- 1.5	.....	.....	29.4	29.47
Do	1-G	413	1.5- 3.0	.....	.....	29.4	30.67
Do	1-G	413	3.0- 4.5	.....	.....	29.8	32.05
		Mile.					
Kings	10-A	4.55	0- 1.5	31	86.75	15.56	10.98
Do	10-A	6.95	1.5- 5.0	32	82.24	20.34	12.25
Do	10-A	3.75	3.0- 4.5	.....	.....	13.72	11.35
Do	10-A	3.75	3.0- 4.5	.....	.....	21.9	14.25
Do	10-A	3.75	4.5- 6.0	.....	.....	19.05	17.63
Do	10-A	3.75	4.5- 6.0	.....	.....	13.82	12.25
Do	10-A	4.55	0- 1.5	.....	.....	15.15	12.07
Do	10-A	4.55	0- 1.5	.....	.....	15.39	12.89
Do	10-A	4.55	1.5- 2.0	.....	.....	18.06	14.56
Alameda	5-B	2.55	0- 1.5	39	71.35	17.7	10.6
Do	5-B	2.55	1.5- 3.0	40	73.06	17.7	11.0
Do	5-B	2.55	3.0- 4.5	41	60.25	22.45	12.4
Do	5-B	2.55	4.5- 6.0	42	65.61	21.3	13.0
Do	5-B	2.55	6.0- 7.5	43	64.39	22.9	15.0
Do	5-B	2.55	7.5- 9.0	44	57.5	26.0	16.7
Do	5-B	2.55	9.0-10.0	45	54.97	26.7	17.6
Do	5-B	4.4	0- 1.5	46	62.04	21.9	14.85
Do	5-B	4.4	1.5- 3.0	47	59.33	21.3	12.4
Do	5-B	4.4	3.0- 4.5	48	57.29	23.5	11.9
Do	5-B	4.4	4.5- 6.0	49	55.23	24.4	12.2
Do	5-B	4.4	6.0- 7.5	50	59.11	21.30	8.75
Do	5-B	4.4	7.5- 9.0	1	68.46	19.67	8.12
Do	5-B	4.4	9.0-10.0	2	65.81	21.89	9.52
Do	5-B	6.0	0- 1.5	3	52.21	27.51	13.95
Do	5-B	6.0	1.5- 3.0	4	52.18	26.08	17.70
Do	5-B	6.0	3.0- 4.5	5	42.75	37.02	30.23
Do	5-B	6.0	4.5- 6.0	6	42.85	33.71	24.50
Do	5-B	6.0	6.0- 7.5	7	36.22	36.45	21.40
Do	5-B	6.0	7.5- 9.0	8	.....	38.58	21.78
Do	5-B	6.0	9.0-10.0	9	39.78	33.29	22.27
Do	5-B	6.7	0- 1.5	10	84.29	13.10	9.22
Do	5-B	6.7	1.5- 3.0	14	82.67	15.48	13.27
Do	5-B	6.7	3.0- 4.5	15	72.47	19.32	18.27
Do	5-B	6.7	4.5- 6.0	16	62.22	24.19	23.92
Do	5-B	6.7	6.0- 7.5	17	49.47	32.13	32.18
Do	5-B	6.7	7.5- 9.0	18	51.54	29.81	27.16
Do	5-B	6.7	9.0-10.0	19	39.77	45.23	29.65
Contra Costa	14-B	23.9	0- 1.5	1	57.95	25.25	16.83
Do	14-B	23.9	1.5- 3.0	2	55.73	28.45	15.43
Do	14-B	23.9	3.0- 4.5	3	57.64	27.06	13.19
Do	14-B	23.9	4.5- 6.0	.....	.....	23.94	10.12
Do	14-B	24.8	0- 1.5	4	75.16	19.72	12.82
Do	14-B	24.8	1.5- 3.0	.....	.....	19.39	9.33
Do	14-B	14	0- 1.5	5	59.09	29.39	14.96
Do	14-B	14	1.5- 3.0	6	57.11	30.73	22.50
Do	14-B	14	3.0- 4.5	7	57.53	30.92	25.69
Do	14-B	14	4.5- 6.0	10	78.40	18.86	20.24
Do	14-B	14	6.0- 7.5	11	52.78	30.51	24.00
Solano	7-B	34.5	0- 1.5	13	61.15	21.59	18.94
Do	7-B	34.5	1.5- 3.0	14	51.33	26.81	24.98
Do	7-B	34.5	3.0- 4.5	15	49.83	33.83	14.26
Do	7-B	34.5	4.5- 6.0	16	62.52	24.91	14.40
Do	7-B	34.5	6.0- 7.5	17	64.49	21.27	15.73

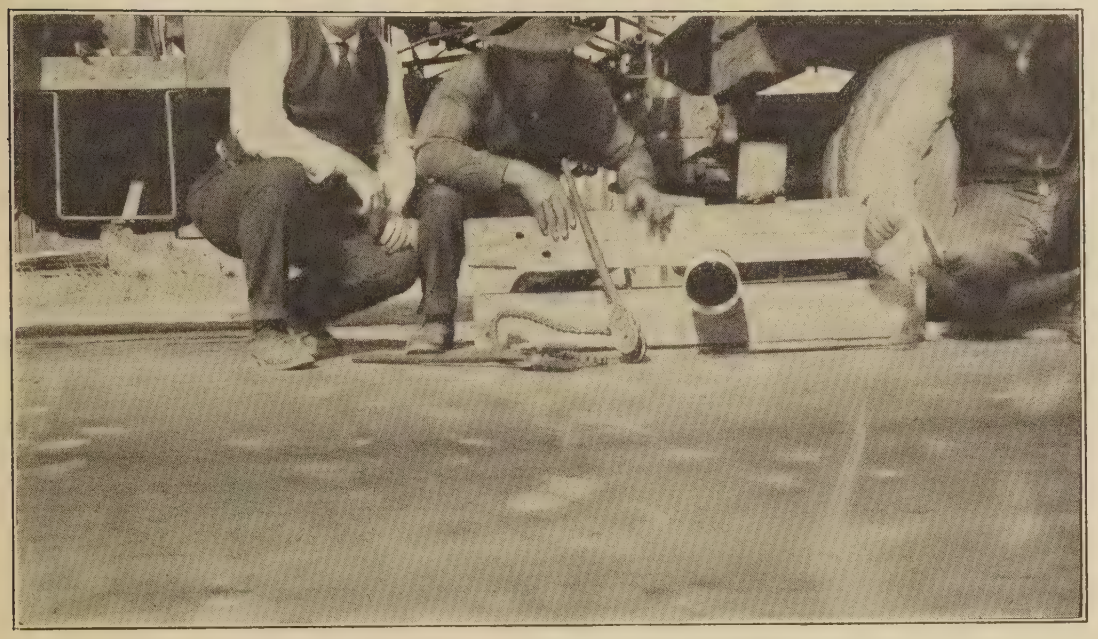
CONCRETE SAMPLE CORES.

Six hundred and thirty-eight concrete test cylinders, 4½ inches in diameter, were drilled from various Portland cement concrete sections on State highway routes numbered 1, 2, 3, 4, 5, 7, 14, and 15, and totaling 800 miles. These cores were drilled in pairs at designated stations, and their locations are shown on the condition diagrams of Appendix H. Each pair was drilled in the pavement about 25 feet apart and on opposite sides of the road and 4 feet from the edge. The designated stations were selected in advance from the plotted condition diagram to represent as well as possible all classes of pavement on the chosen routes. Under each core one or more soil samples were taken to a depth of 6 feet. Two types of core drills mounted on trucks were used—the chilled steel shot drill and the diamond drill (views of the diamond drill are shown in Plate XXIX). The shot drill, loaned by the State, was first tried, but after drilling cores on routes 3, 7, 14, and 15, a total of 187 cores, the diamond drill was used, and it produced not only cores of much better appearance but also was found to work much faster. The sides of the shot-drilled cores were very rough; the mortar frequently was torn out in the process of drilling to a depth of one-fourth inch or more.[12] The sides of the diamond cores, on the other hand, were very smooth. The photographs of both diamond and shot-drill cores, shown in Plates XXX and XXXI, illustrate this point. The average time of drilling the core 4 inches in depth in 1:2½:5 concrete with the shot drill was about 42 minutes—with the diamond drill about 5 minutes.

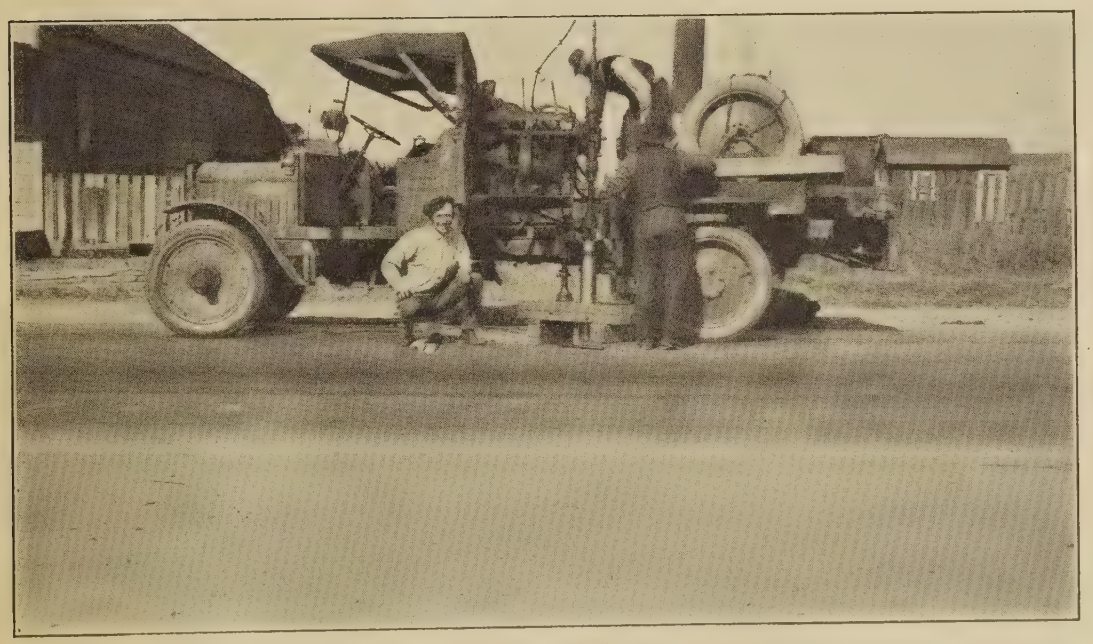
A complete record was kept of the operations of each drill and a copy forwarded with each shipment of cores. Each day the cores drilled were expressed to the United States Bureau of Standards local office in the Appraisers' Building, San Francisco, under an arrange-

[12] A more modern design of the chilled shot drill is said to give better results.

PLATE XXIX.

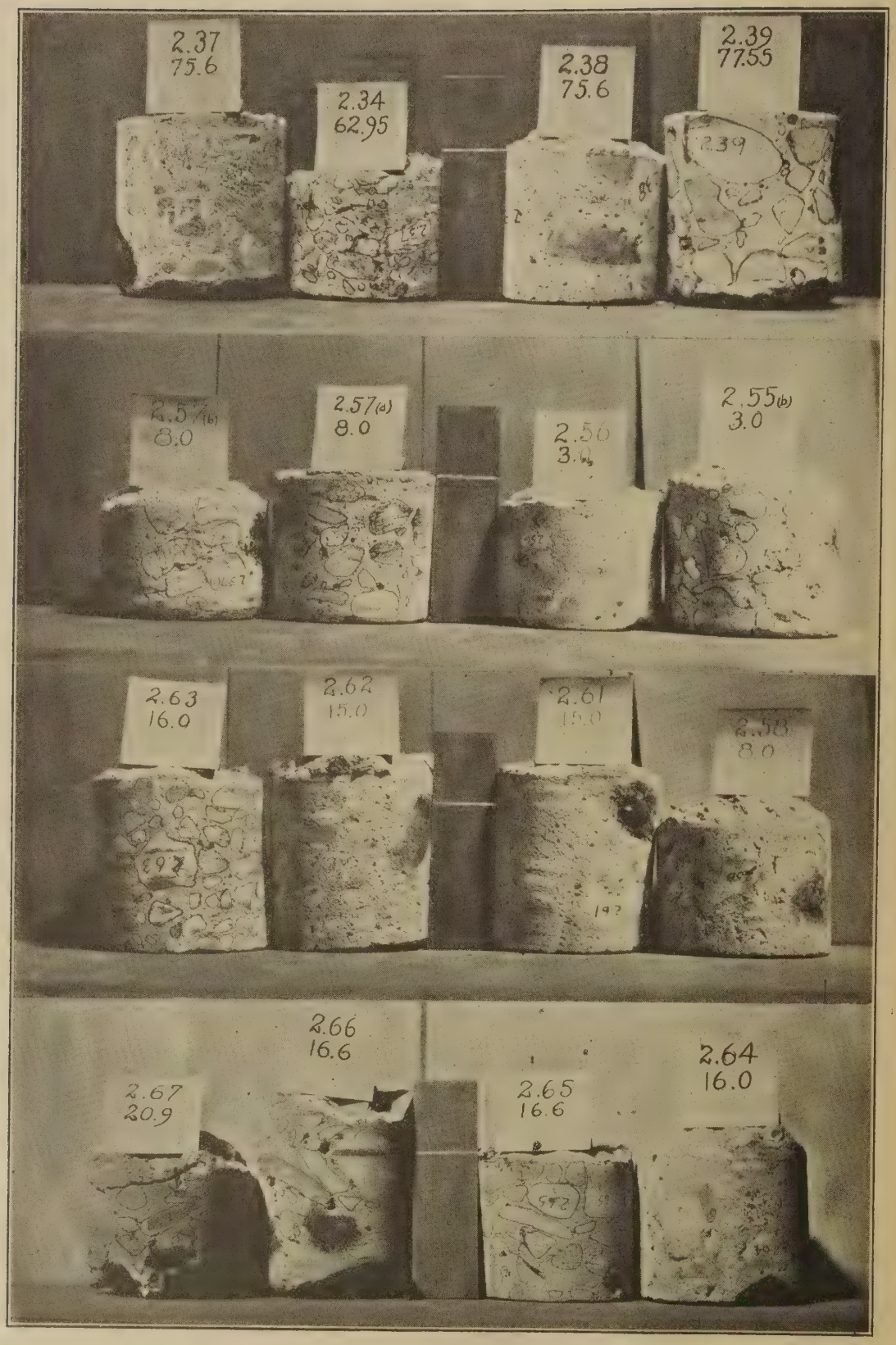


DIAMOND DRILL, SHOWING CUTTING EDGE OF BIT.



GENERAL VIEW OF DIAMOND DRILLING OUTFIT.

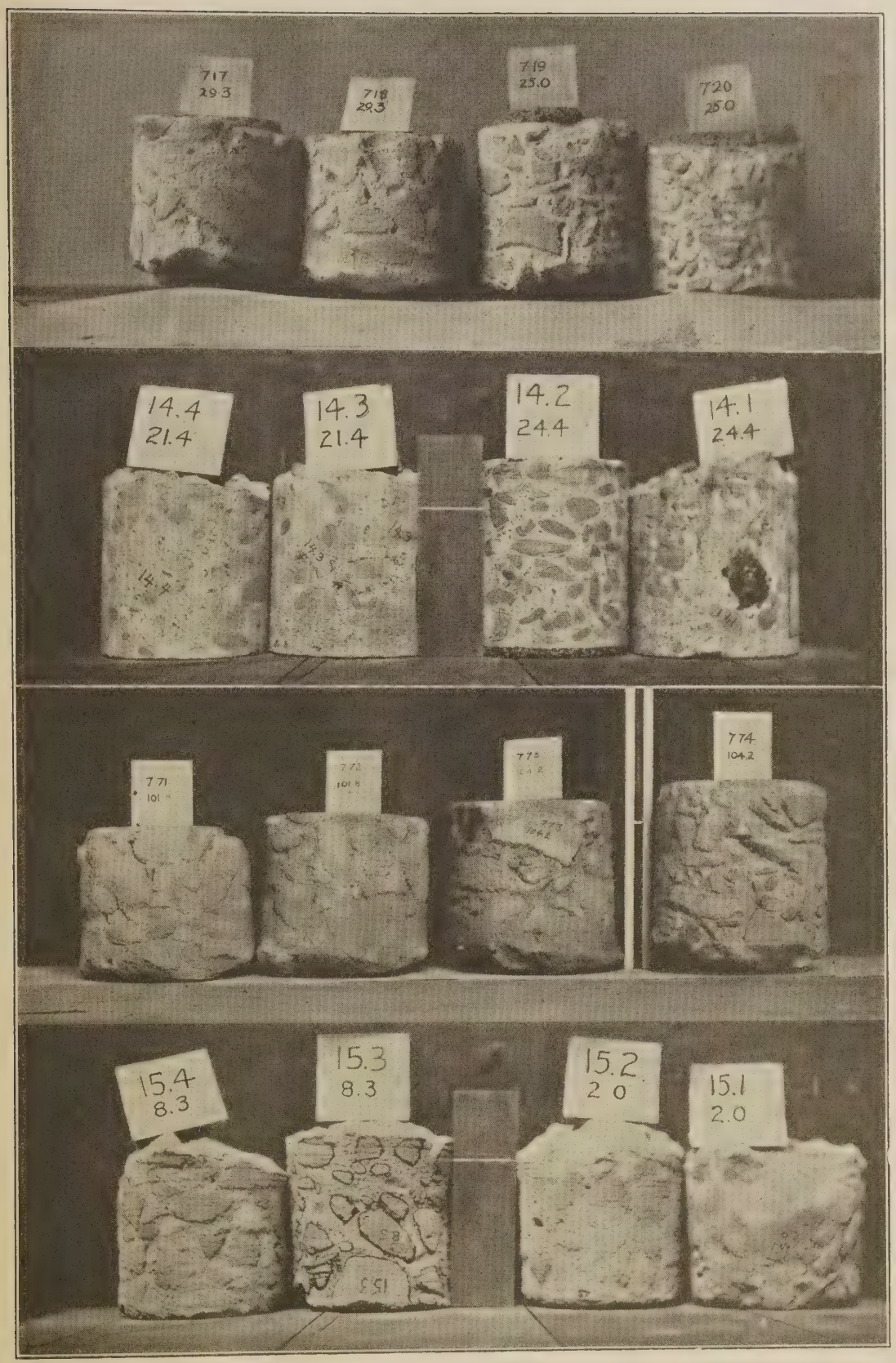
PLATE XXX.



DIAMOND DRILL CORES FROM ROUTE 2.

The upper number on the label shows the route number as a whole number and the core number as a decimal following. The lower number is an identification number. The cores are drilled in pairs for a check and so shown. The location of each core is shown by a corresponding number on the "Condition Diagrams" of Appendix J. The white line on the scale shows the 4-inch height.

PLATE XXXI.



SHOT DRILL CORES FROM ROUTES 7 AND 15 AND DIAMOND DRILL CORES FROM ROUTE 14.

(See note under Plate XXX.)

75712—22——6

ment for cooperation between the two bureaus to do the testing. Thanks to the hearty cooperation on the part of the local representatives of the Bureau of Standards this arrangement worked perfectly.

The cores were subjected to the following tests:

(1) Visual inspection with a complete record of the appearance, distribution, and grading of coarse aggregate and sand, presence of voids, etc.

(2) Cores were photographed in sets of four from opposite sides.

(3) Measurement of maximum diameter and maximum and minimum height.

(4) Planimeter measurements to determine the approximate percentage of coarse aggregate by tracing the exposed areas of coarse aggregate in two 4-inch squares on opposite sides of the core.

(5) Absorption test made by weighing the core in air, immersing in water for 24 hours, surface drying, and again weighing.

(6) Weight per cubic foot by weighing in air (dry), and in air and water after 24 hours' absorption, to determine specific gravity, from which the weight per cubic foot was obtained by multiplying by 62.37.

(7) Compression tests in a 100,000-pound Olsen machine with slow speed of one-tenth inch per minute on cores, both ends of which had been capped with a thin layer of neat Portland cement gaged with a 4 per cent solution of calcium chloride. Previous to capping, the lower surfaces of the cores in sets of about 50 were ground to an approximate plane on a stone grinding table, and after capping they were allowed to rest three days. Cores were cemented temporarily in vertical position during the grinding process by plaster of Paris. The operation of grinding required about two hours.

Of the cores drilled a few were sent to a commercial laboratory and 95 to the division of tests in the Bureau of Public Roads in Washington, D. C. Several irregular-shaped blocks of Portland cement concrete taken from the pavements were also sent to the division of tests.

RESULTS OF TESTS.

(1) A study of the remarks from the visual inspection shows that the cores vary considerably in appearance, both as affecting (*a*) maximum size of the coarse aggregate, (*b*) its distribution, (*c*) coarseness of sand, etc. On the other hand, not very much variation in density is observed. The presence of characteristic air voids along the lower portion of pieces of exposed coarse aggregate is frequently noted. As far as could be noted from this inspection the maximum size of coarse aggregate varied from slightly over 2 inches down to three-fourths inch. The sand, as a rule, was well graded and clean, the one outstanding exception to this being on route 2, Los Angeles County, Section C. In this section three out of six cores were broken during the process of drilling, and examination showed the presence of dirty sand. The three cores which came out whole showed very low compression tests. The concrete after fracture indicated dirt in the mortar.

(2) The photographic record was of value in checking notes of visual inspection particularly relative to the size and distribution of coarse aggregate. Photographs of typical sets are shown in Plates XXX and XXXI.

(3) Shot cores varied in diameter from 4.4 to 4.6 inches, as near as could be measured by calipering. The diameter of the diamond cores on the other hand was practically constant at 4.5 inches. The height of the cores showed the thickness of pavement, and where the nominal thickness was 4 inches the cores varied all the way from 3 to 5 inches. As a rule, however, the average variation in the depth of core in any given contract is not more than 0.5 inch, and was generally greater rather than less than the nominal depth of the pavement.

(4) Planimeter measurements to ascertain the percentage of coarse aggregate were taken on 194 cores on routes 4, 7, and 14 and part of route 2. The average percentage of coarse aggregate as determined by this method (assuming the volumes proportional to areas) is shown in Table 25. It will be noted that the average percentage in all cases is approximately 50, which is, theoretically, about the average of solid stone in a given volume of either 1:2:4 or 1:2½:5 concrete, assuming 45 per cent voids. Individual planimeter measurements varied from less than 30 to more than 60 per cent. The great majority, however, were within 5 per cent of the general average of 50. Typical core tracings are shown in Plates XXXII and XXXIII.

(5) Absorption tests showed a variation in percentage of absorption from somewhat less than 1 per cent in rare cases to about 2½ per cent, the average being about 1½ per cent. There appeared to be very little relation between the percentage of absorption observed and other physical characteristics of the cores.

(6) Weight per cubic foot determinations showed results varying from 140 to 160 pounds per cubic foot. Cores 2.66, 2.67, and 2.70, which have been noted above in connection with the presence of dirty sand in the mortar, showed a weight per cubic foot of 132 pounds. With this single exception, however, all the cores tested averaged very close to 150 pounds per cubic foot.

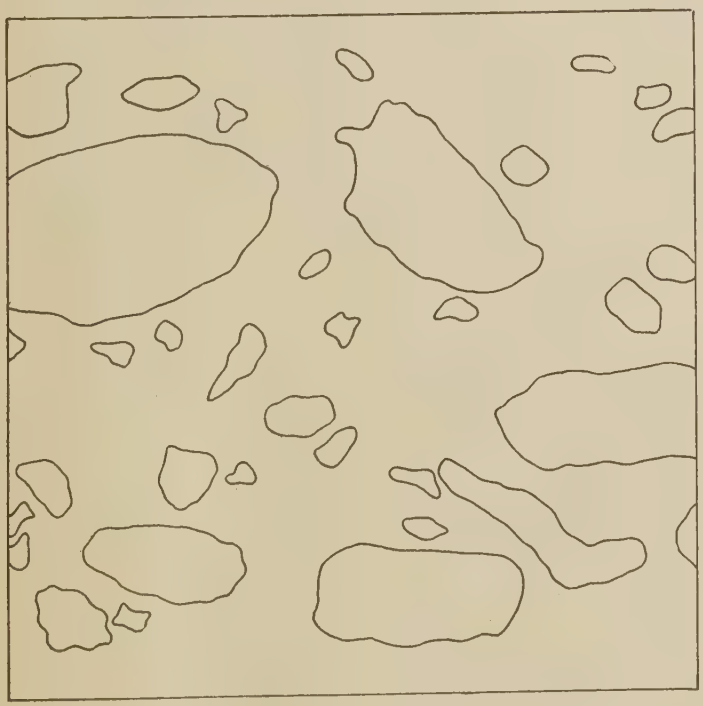
(7) Examination of the concrete specimens after the compression test showed, as a rule, that the coarse aggregate was sound and of good quality, composed of a

PLATE XXXII.

TYPE OF GRADING AND DISTRIBUTION OF COARSE AGGREGATE

A SERIAL 4.33
MILE 54.5

PERCENTAGE OF
COARSE AGGREGATE
63.0%



A SERIAL 4.27A
MILE 51.2

PERCENTAGE OF
COARSE AGGREGATE
29.5%

PLATE XXXIII.

TYPE OF GRADING AND DISTRIBUTION OF COARSE AGGREGATE

B SERIAL 4.117
MILE 77.6

PERCENTAGE OF
COARSE AGGREGATE
47.7 %

B SERIAL 4.99
MILE 4.40

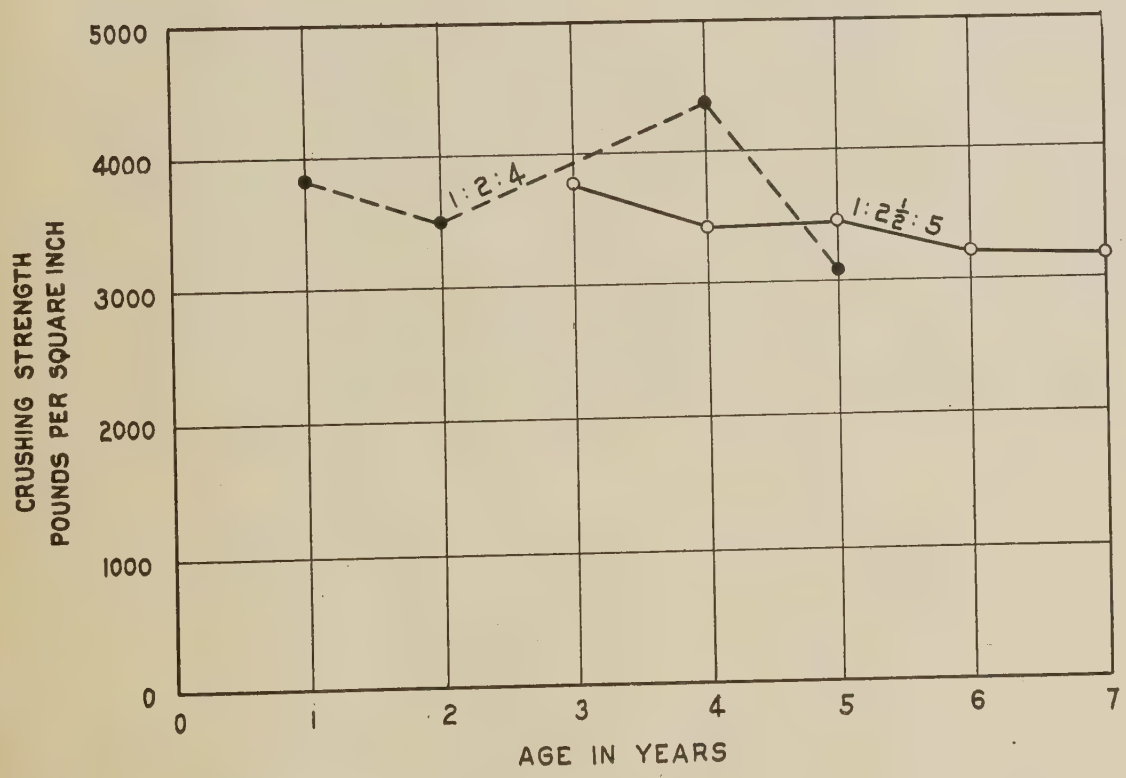
PERCENTAGE OF
COARSE AGGREGATE
32.8 %

PLATE XXXIV.

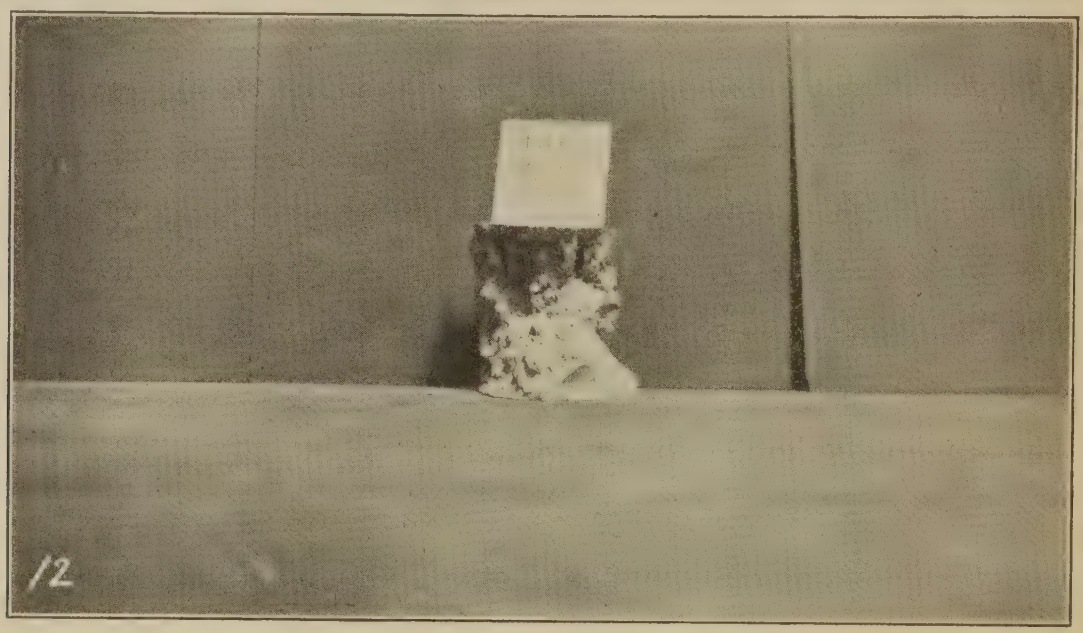
DIAGRAM
SHOWING
RELATION BETWEEN AGE OF CONCRETE IN YEARS AND CRUSHING STRENGTH

NUMBER OF TESTS AVERAGED

YEAR	1:2:4 MIX	1:2½:5 MIX
1	52	—
2	62	—
3	—	12
4	6	123
5	8	114
6	—	88
7	—	16



mixture of crushed and uncrushed fragments of gravel. The mineral composition of the coarse aggregate varied considerably. The prevailing types, however, were trap, slate, quartzite, and sandstone. The fine aggregate in general was clean and of good quality and well graded. The concrete as a whole was fairly dense, and only in comparatively few cases gave evidences of having been mixed with a large excess of water. Average results of compression tests of the concrete averaged according to mix, age, and class of pavement are shown in Table 26 and are plotted in the diagram on Plate XXXIV. Averaged by routes the results are shown in Table 27. The strength of the concrete is very nearly constant for all pavement classes, and, with the exception of class A, the average for 1:2:4 concrete for the various classes is higher than for the 1:2½:5. The general average for both 1:2½:5 and 1:2:4 concrete decreases with age with the exception of 1:2:4 concrete at four years and 1:2½:5 concrete at five years. In the case of 1:2:4 concrete only six specimens were tested at the age of four years, which may account for the comparatively high results. In general there seems a slight tendency for the concrete to decrease in strength with age. This general tendency follows also within the various pavement classes, although there are several exceptions.



CRUSHED CORE AFTER TEST.

REMARKS ON TESTS OF CORES.

Individual results in compression considerably lower than the general average were noted in the following cases:

Section C, Los Angeles County, route 2: In this section three cores were secured after six trials; the other three cores crumbled during drilling. The three cores tested showed crushing strengths of 2,190, 2,020, and 1,685 pounds per square inch—much lower than the general average. An inspection of all cores showed the presence of considerable dirt in the sand which may be the cause of the low strength obtained.

In Orange County, Section B, of route 2, four cores (serial Nos. 13, 14, 15, and 16) were taken, two of which broke during the drilling operation. The other two cores, however, showed strengths considerably over 3,000 pounds per square inch, although the broken concrete indicated that the sand contained considerable dirt. The other cores tested from Orange County, Section B, showed strengths averaging 2,600 pounds per square inch.

In Stanislaus County, Section A, route 4, cores 17 and 18 gave strengths of 2,550 and 2,510 pounds per square inch, respectively. The concrete after failure indicated a rather fine sand. The concrete was also more porous than the general average.

In Merced County, Section C of route 4, serial No. 27, showed a crushing strength of 2,065 pounds per square inch. The only distinguishing characteristic of this core was that it showed a very small percentage of coarse aggregate—36 per cent.

In Madera County, Section A of route 4, cores 53 and 54 gave crushing strengths of 1,690 and 1,470 pounds per square inch. There were no unusual characteristics about this concrete to account for the low strength obtained. It is possible, however, that in this one case the oil skin top was allowed to remain in place during test, which would account for the low results.

In Glenn County, Section A of route 7, cores 62, 63, 65, and 68 showed considerably lower strength than the average, or about 2,100 pounds per square inch.

There were no unusual characteristics of the concrete, however, which would indicate the reason for the low strength, except that the presence of alkali crusts raises the question as to possible injury to the concrete by alkali in either the wet subsoil or in the mixing water. Other cores on Glenn County, Section A, showed strengths averaging 3,000 pounds per square inch.

The general high average quality of the concrete is indicated by the fact that out of a total of 481 samples tested only 1 per cent gave values for crushing strength less than 2,000 pounds per square inch, and only 8 per cent less than 2,500 pounds per square inch. The general average of all 1:2:4 specimens is 3,640 pounds per square inch, and of all 1:2½:5, 3,370 pounds per square inch.

Since specimens were of different heights, it was impracticable to test standard size specimens. To obtain some idea of the effect of height of specimen on the crushing strength, 30 special cores were drilled from class A pavement, route 2, Santa Barbara, Section B, 1:2½:5 concrete, four years old. These cores were tested as follows:

Four at 3½ inches in height.
Five at 4 inches in height.
Five at 4½ inches in height.
Five at 5 inches in height.
Five at 6 inches in height.

The results are given in the column headed "Observed values" in Table 28, showing comparative compression tests of concrete check cores. It will be noted that except in a very general way there is no relation between height of specimen and the crushing strength.[13] These values could, therefore, not be used in deriving a law for correcting the strengths obtained on the routine specimens.

To correct the observed values of crushing strength for varying height of specimen, the comparative results obtained by a committee of the American Concrete Institute on "Specifications and Methods of Tests for Concrete Materials" were used.[14] All values for crushing strengths given in the following tables, as well as all individual results noted, have been corrected according to methods given in the above report, and are the equivalent crushing strengths which would be obtained on cylinders 4½ inches in diameter by 9 inches in height. The "corrected values" in the comparison table indicate that after eliminating the effect of height of specimen there still remains a considerable variation in the strength of concrete, even when the specimens are taken from a relatively small pavement area.

[13] Doubtless the actual variation in the quality of the concrete in different spots in the pavement was greater than the variation caused by the difference in height of tested specimen.

[14] Report of this committee is given on page 422 of the October–November (1914) edition of the Journal of the American Concrete Institute.

TABLE 25.—*Showing per cent of coarse aggregate in concrete cores by planimeter measurement.*

PERCENTAGE OF COARSE AGGREGATE.

Route.	1:2:4 mix.	1:2½:5 mix.	Remarks.
2	48 (4)	50 (28)	Measurements taken on odd numbered cores only.
4	50 (17)	48 (52)	Do.
7	49 (11)	50 (60)	Measurements taken on all cores.
14	50 (12)	53 (10)	Do.
Average.	50 (44)	49 (150)	

Figures in parentheses indicate number of specimens averaged.
Average variation between measurements of two sides of core about 3 per cent.
Average variation between measurements of check cores about 5 per cent.

TABLE 26.—*Showing average compression tests of concrete averaged by mix, age, and class of pavement.*

MIX 1 : 2½ : 5.

Class of pavement.	Age in years.					Average by classes.
	3	4	5	6	7	
A	4,085 (2)	3,780 (11)	3,460 (30)	3,390 (27)	3,235 (4)	3,490 (74)
B	3,040 (4)	3,660 (40)	3,540 (30)	3,310 (15)	2,740 (2)	3,510 (91)
C	.....	3,370 (30)	3,160 (29)	3,120 (20)	3,340 (4)	3,230 (83)
D	3,240 (2)	3,090 (25)	3,650 (12)	2,990 (4)	.....	3,240 (43)
E	4,560 (4)	3,070 (8)	3,780 (7)	3,210 (8)	.....	3,520 (27)
F	.....	2,980 (9)	3,660 (6)	2,980 (14)	3,190 (6)	3,140 (35)
Average, by years.	3,755 (12)	3,390 (123)	3,450 (114)	3,220 (88)	3,180 (16)	3,370 (353)

MIX 1 : 2 : 4.

Class of pavement.	Age in years.				Average by classes.
	1	2	4	5	
A	3,470 (6)	3,560 (12)	.....	2,940 (2)	3,470 (20)
B	3,740 (24)	3,650 (14)	.....	3,080 (6)	3,610 (44)
C	3,950 (6)	3,490 (17)	.....	.....	3,650 (23)
D	4,430 (1)	3,460 (13)	4,440 (6)	.....	3,800 (20)
E	4,060 (9)	3,130 (6)	.....	.....	3,700 (15)
F	3,890 (6)	.....	.....	.....	3,890 (6)
Average by years ..	3,810 (52)	3,500 (62)	4,440 (6)	3,045 (3)	3,640 (128)

NOTE.—Figures in parentheses indicate number of tests averaged.

Results are equivalent values for specimens 4½ inches in diameter by 9 inches high.

TABLE 27.—*Showing average compression tests of concrete averaged by mix, route, and class of pavement.*

Route.	Class of pavement.	Mix. 1 : 2 : 4	Mix. 1 : 2½ : 5	Route.	Mix. 1 : 2 : 4	Mix. 1 : 2½ : 5
1	A	3,635 (2)	.....	2	4,020 (2)	3,250 (24)
	B	.....	4,365 (2)		3,650 (16)	3,695 (18)
	C	3,030 (2)	.....		4,440 (7)	3,245 (33)
	D	.....	.....		4,110 (14)	3,430 (22)
	E	4,465 (5)	4,560 (4)		3,555 (4)	3,730 (12)
	F	4,905 (2)	.....		3,390 (4)	3,270 (15)
Average		4,140 (11)	4,495 (6)		3,890 (47)	3,435 (124)
3	A	3,190 (2)	3,170 (12)	4	3,470 (14)	3,320 (19)
	B	4,260 (8)	2,795 (12)		3,290 (14)	3,280 (34)
	C	.....	3,775 (6)		3,940 (1)	3,010 (24)
	D	.....	4,730 (1)		2,815 (2)	3,245 (4)
	E	.....	.....		3,065 (4)	2,850 (2)
	F	.....	.....		.....	3,065 (12)
Average		4,042 (10)	3,790 (31)		3,385 (35)	3,185 (95)
5	A	.....	.....	7	.....	3,465 (13)
	B	4,020 (2)	4,410 (4)		3,080 (4)	3,360 (23)
	C	3,910 (4)	3,225 (5)		2,335 (2)	3,150 (13)
	D	.....	3,395 (2)		.....	2,785 (12)
	E	.....	.....		.....	3,180 (6)
	F	.....	2,985 (2)		.....	2,690 (4)
Average		3,945 (6)	3,580 (13)		2,830 (6)	3,180 (71)
14	A	.....	3,580 (1)	15	.....	4,130 (3)
	B	.....	.....		.....	.....
	C	3,090 (7)	3,815 (4)		.....	.....
	D	3,230 (4)	.....		.....	3,360 (1)
	E	3,255 (2)	.....		.....	3,485 (2)
	F	.....	.....		.....	3,615 (2)
Average		3,160 (13)	3,760 (5)		.....	3,745 (8)

Figures in parentheses indicate number of specimens averaged.

NOTE.—Results are equivalent values for specimens 4½ inches in diameter by 9 inches high.

GRADED ROAD. ROUTE 3 SHASTA COUNTY.

TABLE 28.—*Table showing comparative compression tests of concrete check cores.*[1]

Height of specimen when tested (inches).	Crushed strength (pounds per square inch).		Height of specimen when tested (inches).	Crushed strength (pounds per square inch).	
	Observed values.	Corrected values.		Observed values.	Corrected values.
3.5	4,940	2,980	5.0	3,940	3,150
	5,940	3,580		3,750	3,000
	4,325	2,600		3,450	2,760
	5,545	3,340		4,920	3,940
				3,920	3,140
Average	5,190	3,125	Average	3,995	3,200
4.0	6,380	3,630	6.0	5,420	4,710
	4,000	2,700		3,930	3,420
	6,040	4,080		3,910	3,400
	5,650	3,820		5,230	4,550
	5,270	3,560		3,890	3,380
Average	5,150	3,560	Average	4,475	3,890
4.5	6,175	4,680			
	4,690	3,550			
	4,540	3,440			
	4,535	3,440			
	5,040	3,820			
Average	4,995	3,785			

[1] See note under table 27, p. 87.

NOTE.—Results under "corrected values" are equivalent values for specimens 4½ inches in diameter by 9 inches high.

Specimen cores were taken from class A pavement on route 2, Santa Barbara County, Section B, 1 : 2½ : 5 concrete, age 4 years.

GRADE, ALIGNMENT, AND LOCATION.

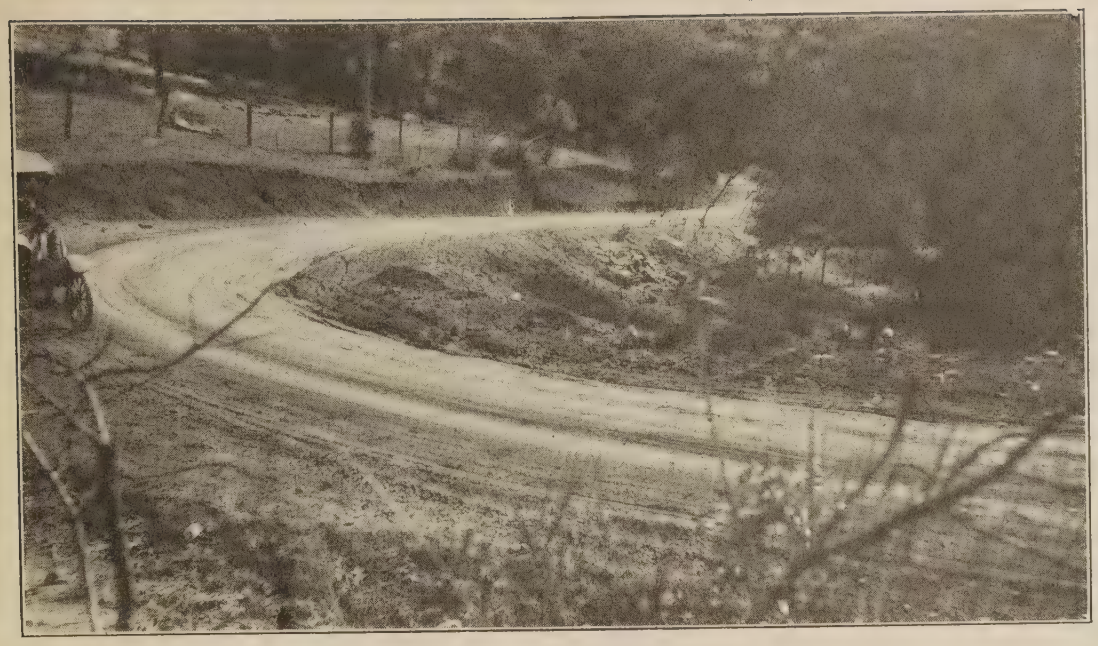
Nearly all the graded and unpaved section of the main routes built by the commission were carefully inspected with respect to location features. Such features were also specially investigated on selected paved roads. These location inspections covered particularly route 14 in Contra Costa County (Eckley to Martinez), route 7 in Solano and Yolo Counties, route 1 from Sausalito to Willits, and route 4 in Los Angeles County, also route 3 from Sacramento to the Oregon line. In addition location features were also examined in connection with all field inspections made to check the preliminary pavement classification. Grade and alignment in all cases were particularly studied and with respect to (*a*) present traffic conditions, (*b*) topography, and (*c*) right-of-way limitations.

No attempt was made to classify location. Much of the road inspected is above criticism. There follow a few examples of location features that demand notice.

Contra Costa, 14–B (Eckley-Martinez).—On this section are short radii, blind curves, and excessive rise and fall. Probably more than a mile of distance could have been eliminated in the four easterly miles.

Solano 7 and Yolo 7 (Benicia-Sacramento).—There are some locations on this road that indicate too close an adherence to the old rights of way, notably between Fairfield and Vacaville. North of Dixon are two right angle turns in order to follow section lines, and this is repeated north of the Yolo County line.

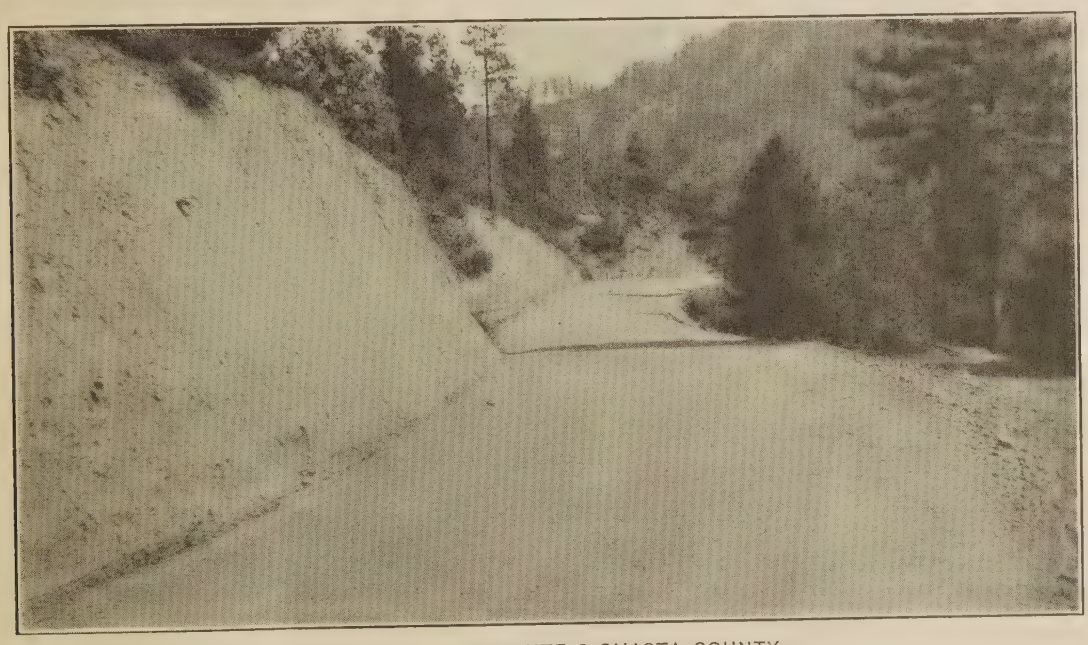
Route 1 (Sausalito-Willits).—From Sausalito to Larkspur the road presents excessive curvature and impaired vision. The alignment appears to be worth straightening to make this trunk line less slow and less dangerous. From Cloverdale to the north line of Sonoma County (1–A), a sweeping revision is indicated as very desirable in order to eliminate both blind curvature and the switch-back at stations 29 and 50 and to avoid the development from station 185 to the end of the project by a heavy cut in the saddle near station 202. On Section A in Mendocino County a route of less than 7 per cent grades might have been found along the Russian River between Cloverdale and Hopland, but heavy mud slides would have been encountered. On Section D in Mendocino County a new line in certain places is under construction to eliminate curvature and heavy grade, and such work could advantageously be continued in other places.



POOR ALIGNMENT. 1 MENDOCINO D.

Los Angeles, 4–B, 4–C, and 4–D.—This is the Ridge Road over the Tehachapi Mountains and is built on higher standards than other mountain roads. Curves of less than 100-foot radius have seldom been allowed and the vision has been improved by cutting the inside banks to within 3 feet of grade. The road is paved 20 feet wide and the curves carefully superelevated. Some straightening could have been done and some of the alignment improved as work progressed.

Route 3, from Sacramento to the Oregon line, presents much excellent location, and the elimination of grade crossings in Division II is specially commendable. There are, nevertheless, many curves which, in the light of present conditions, should have been made easier. Some of the blind curves from the summit north of Redding and toward the Pitt River bridge occur in relatively steep grades. The good location so generally obtains, however, that it serves to emphasize the inconsistency.



GRADED ROAD. ROUTE 3 SHASTA COUNTY.

In several instances, notably on route 3 in Butte County, the floors of small bridges are noticeably rough but serve as a pavement. The connection with the adjacent pavement is often quite uneven, and it would appear possible to eliminate this condition by lowering the floors of bridges and carrying the pavement continuously across.

ECONOMIC AND OTHER STUDIES

GENERAL ECONOMIC FEATURES.

California, the second largest State, had in 1910 a population of 2,377,549 and ranked twelfth. The 1920 census figures indicate the present population as 3,426,536. The increase is 44 per cent. In 1910 only 36 per cent of the people were classed as rural, so the population was largely in cities and towns.

The topography in general may be characterized as one great interior valley and numerous small valleys, all surrounded by the Coast Range and the Sierra Nevada and Siskiyou Mountains. The Sierra Nevada Mountains are highest in the southwest, between Tulare Lake and Owens Lake, and on to Nevada. The northern counties are generally mountainous. These features are shown to a distorted vertical scale in the frontispiece.

The main valley is subdivided into the Sacramento River Valley in the north and the San Joaquin River Valley in the south. There are numerous small agricultural valleys, but these two valleys, with the Santa Clara Valley south of San Francisco and the valley lands south of the Tehachapi Mountains, are the principal agricultural lands of the State.

The agricultural products of the State were valued by the 1910 census at $153,111,013; they have since greatly increased, and in 1920 may be conservatively estimated at $539,000,000. The acreage of improved farm land in 1910 was approximately 11,389,894.

The value of mineral and timber products in 1910 was estimated at $63,382,454.[15]

There are about 1,000 miles of coast, and besides the harbor of San Francisco there are harbors at Monterey, Los Angeles, San Diego, Eureka, and Crescent City. Commerce with the Orient, Australia, New Zealand, and South America is extensive, and is supplemented by coastwise shipping and European cargoes through the Panama Canal. The bank clearings at San Francisco for August, 1920, were $645,480,714. The State ranks eighth in exports.

The climate of California is characterized by the virtual absence of snow or frost except in the mountains. There is considerable winter rainfall in the northern counties, particularly on the coast. In San Francisco the average rainfall for normal years is 22.27 inches. This precipitation occurs largely in the interval October 15 to March 15. In Sacramento the average rainfall is 20.09 inches for normal years, in San Diego, 10.01 inches. The summers in the big valleys are hot, with unbroken sunshine.

Railroad transportation in the State is adequate, and is furnished by the Southern Pacific from the Oregon line straight through the great Sacramento and San Joaquin Valleys and over the Tehachapi Pass to Los Angeles, thence through the San Bernardino and Imperial Valleys to Yuma, Arizona. The main line east also connects San Francisco with Sacramento and Reno, Nevada, and the coast route traverses the Santa Clara and Salinas Valleys to Los Angeles. The Sante Fe enters the State from the east at Needles, and crosses the fruit belt around San Bernardino, thence across the Tehachapi Pass, and down the San Joaquin Valley to Sacramento and San Francisco. A branch runs to Los Angeles and San Diego. The State is also crossed by the Western Pacific and the Salt Lake roads, and there are smaller roads, including the Northwestern Pacific through the Sonoma Valley north of San Francisco, the San Diego and Arizona, connecting San Diego and the Imperial Valley with the coast, and various electric interurban lines.

There are numerous motor truck freight lines and autobus passenger stage lines which are described below.

MOTOR VEHICLES—GENERAL.[16]

The California Highway Commission is directed by law, as previously mentioned, to expend one-half the net motor-vehicle registration receipts for maintenance and improvement of State highways.[17]

The commission is also authorized to issue special written permits for loads in excess of those permitted by the motor vehicle law, to proceed over State highways or bridges, and also to reduce the maximum permissible loads on particular highways and bridges under special conditions.

The commission is also charged with the duty of providing forms upon which county supervisors shall report expenditures from their one-half of the net motor-vehicle fund returned to the respective county funds. With reference to these county expenditures, the commission states in the first annual report that the forms prepared were somewhat complicated and the returns extremely crude. There was an indication that the vehicle money was merged with other county funds and it seemed to be a general practice to divide the money into five parts—one for each supervisor's district—and thus to dissipate the revenue.

There has been a rapid and large increase in motor-vehicle registration and use in California since 1907

[15] These figures are compiled from reports of the U. S. Census, of the State controller, State commission of horticulture in cooperation with U. S. Bureau of Crop Estimates, annual reports California Development Board, statistical reports California State Board of Agriculture, etc.

[16] A summary of motor-vehicle legislation in California will be found in Appendix C.

[17] Also for maintenance and improvement of roads in State parks under certain conditions.

and corresponding increase in the motor-vehicle fund. This progress of registration and revenue is shown in Table 29.

TABLE 29.—*Approximate total motor-vehicle registration and revenues in California, by years.*[1]

Years.	Total.	Trucks only.	Increase, by years.	Total license receipts.
1907	[2] 10,020			
1907	14,051		4,031	
1908	19,561		5,510	
1909	28,633		9,072	
1910	44,122		15,489	
1911	60,779		16,657	
1912	91,194		30,415	
1913	118,716		28,522	
1914	123,516	6,156	3,800	$1,343,110
1915	163,795	8,189	40,279	2,059,683
1916	235,440		68,645	2,192,790
1917	310,916		75,476	2,846,030
1918	370,800	13,953	53,884	3,540,306
1919	493,463		128,663	4,468,721
1920	[3] 545,000	[4] 32,555	51,537	[5] 4,922,250

[1] Total automobiles and trucks from the records of the secretary of state, 1907–1913, and from those of motor vehicle department for 1914–1920. Trucks only from other sources except for years 1918 and 1920.
[2] Prior to April 8, 1907.
[3] Estimated for calendar year 1920 from registered automobiles and trucks to July 3, 468,211, and to Sept. 24, 507,255, and exclusive of 8,107 U. S. Government and other motor vehicles exempt from license fees.
[4] Trucks to Sept. 24 and with solid tires only. About 6,200 trucks additional with neumatic tires estimated June, 1920, are included in the column headed "Total."
[5] Estimated at 1919 average per vehicle.

The progress of registration is also shown by Plate XXXV, which also presents for comparison a curve of total registration progress in the entire United States since 1906.

In Plate XXXVI is shown the relative progress of motor-vehicle registration in the five leading States, including California, from 1914 to 1919.

TRAFFIC COUNTS.

Traffic counts were made to determine in a short interval (*a*) an index to the usefulness of the State highways to the people of the State and (*b*) a measure of the relation of travel to the condition of the constructed roads.

The principal traffic counts were taken during an interval equivalent to one day of 16 consecutive hours, from 6 a. m. to 10 p. m., at 103 stations between August 7 and October 14. Supplementary counts were also taken.

To check the positions selected for the 103 traffic stations for the principal one-day count, the California State Highway Commission independently selected 187 traffic stations which were compared with the 103 stations already selected, and the latter were found sufficiently in accord with the State selections so that no extensive changes were required. The positions of the stations used are shown on the State map, Plate XXXVII. The traffic blank used is shown in Appendix E.

Traffic diagrams of the State routes were prepared from the record of these counts. These diagrams, which are shown in Appendix G, were made with a horizontal scale of 20 miles to the unit, and the total numbers of vehicles of all kinds counted at the various stations were plotted as ordinates. The ordinates were subdivided to show (*a*) the number of all motor trucks, (*b*) the two-way division of travel (either north and south or east and west).

It will be seen that most of the traffic stations were near towns and thus their result "peaks" of travel corresponding roughly to the size of the town and incidentally showing the relative importance of local travel. It is noteworthy also that the flow of traffic both ways tends to balance. The sum of the areas beneath the total traffic curve gives the approximate total number of vehicle-miles for a 16-hour day, counted between August 7 and October 14 on the system of California State highways. This total is 2,582,201 vehicle-miles and about seven-tenths occurs on the State-constructed paving.

This daily figure represents summer traffic when the movement of agricultural produce and tourist traffic may be assumed to be highest. On the other hand, it omits excess Sunday traffic and all night traffic from 10 p. m. to 6 a. m. It is also based on the "traffic curve," which is a combination of straight lines which shape tends to reduce the total vehicle-miles near centers. This summer interval extends roughly from June 1 to November 1. Using the total daily traffic-miles as 2,500,000 for this interval of, say, 150 days only, results in a total of 375,000,000 vehicle-miles.[18] For the remainder of the year another index traffic count is required. These figures as stated neglect all special occasions night traffic, and extra Sunday traffic, which tend to increase them, rainy days, etc., which affect this increase.

The resulting average of the different kinds of traffic for one equivalent 16-hour week day throughout the State is shown in the following table:

Table showing average 16-hour week day traffic at 103 stations.

Type.	Average vehicles.	Per cent of total traffic.	Per cent of total trucks.
Light automobiles	472	34.10	
Heavy automobiles	674	48.50	
Passenger busses	31	2.20	
Trucks, class 1	73	5.30	42.40
Trucks, class 2	41	3.00	23.70
Trucks, class 3	28	2.00	16.20
Trucks, class 4	29	2.10	16.80
Horse-drawn traffic	32	2.70	
Extra heavy traffic	2	.10	1.10
Total of all vehicles	1,387	100.00	100.00
Total of trucks, only	173		

Trucks, class 1: Less than 1 ton with pneumatic and less than ¾ ton with solid tires.
Trucks, class 2: One to 2½ tons with pneumatic tires and ¾ to 1½ tons with solid tires.
Trucks, class 3: Three to five tons with pneumatic tires and 2 to 3 tons with solid tires.
Trucks, class 4: Five tons plus with pneumatic tires and 3 tons plus with solid tires.

[18] This figure is supported by the estimated gasoline consumption of 22,000,000 gallons per month by motor vehicles. At 10 miles per gallon for five months, if one-third of the resulting motor-vehicle mileage is on the State highway, there results 367,000,000 vehicle-miles.

PLATE XXXV.

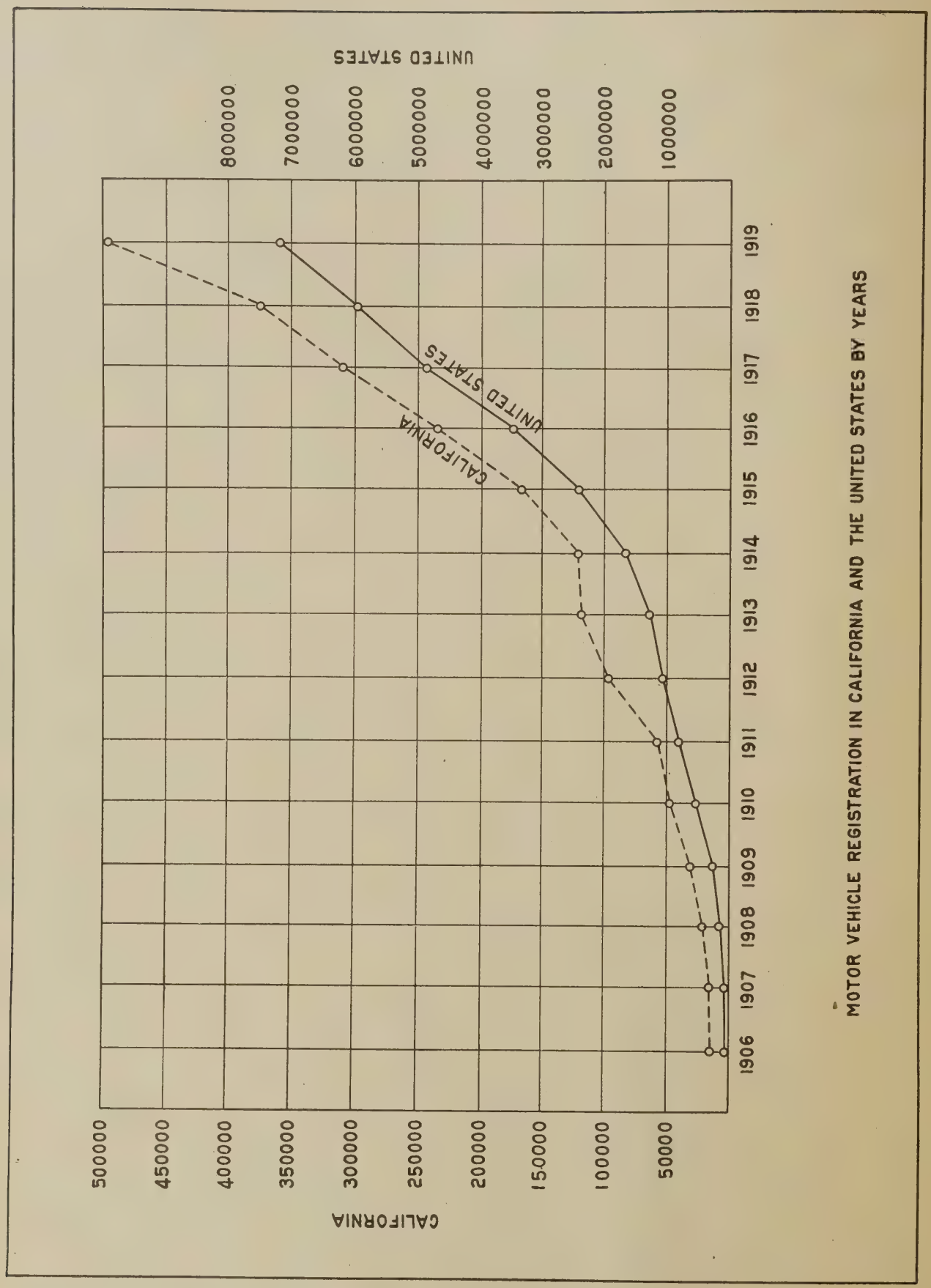
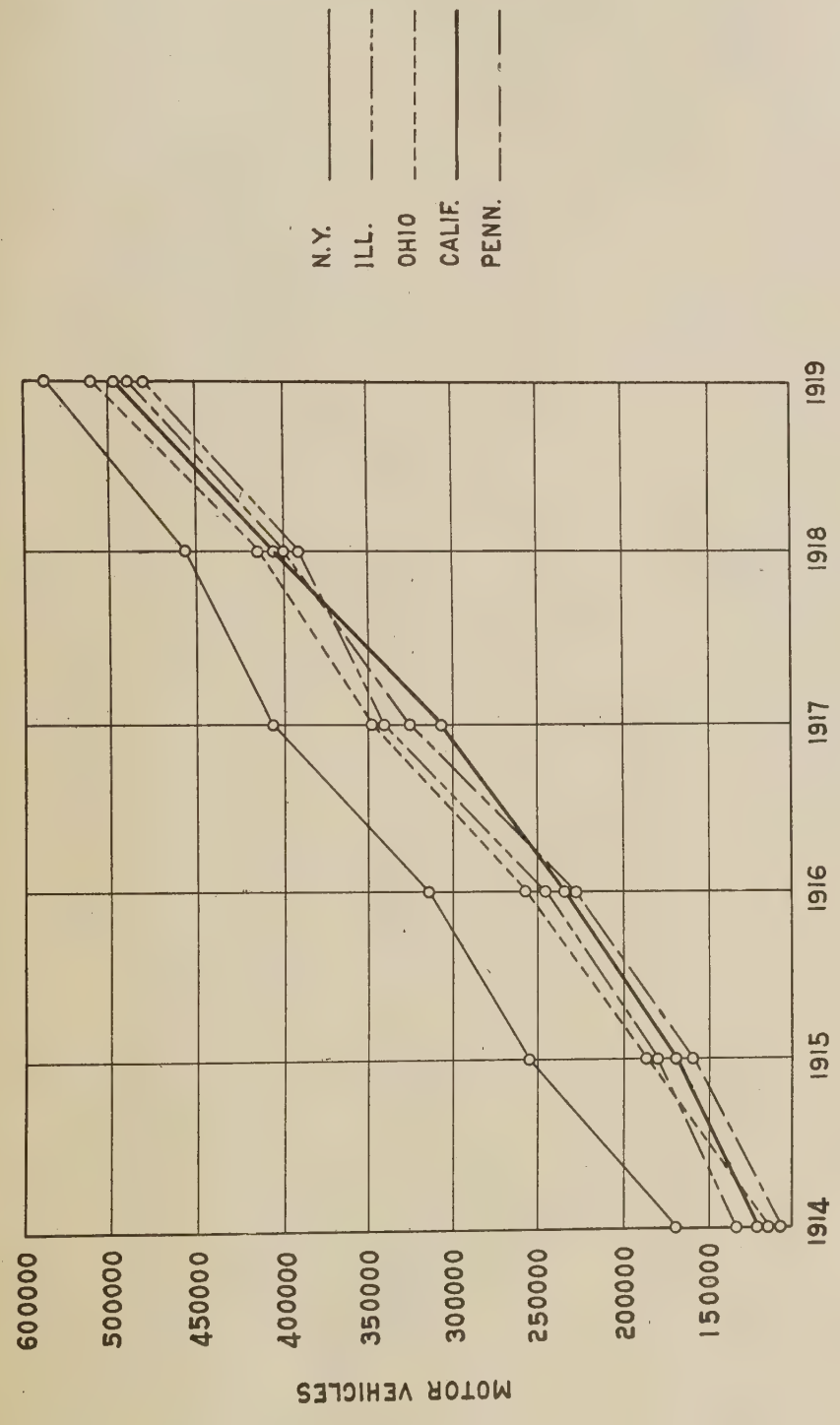

MOTOR VEHICLE REGISTRATION IN CALIFORNIA AND THE UNITED STATES BY YEARS
CALIFORNIA
UNITED STATES
500000
450000
400000
350000
300000
250000
200000
150000
100000
50000
8000000
7000000
6000000
5000000
4000000
3000000
2000000
1000000
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
CALIFORNIA
UNITED STATES

PLATE XXXVI.



MOTOR VEHICLE REGISTRATION IN FIVE LEADING STATES 1914-1919

PLATE XXXVII.

From the traffic diagrams it is apparent that the duty of the State highways is preponderantly to carry motor vehicles—horse-drawn traffic is actually only 2.7 per cent of the average daily traffic at the 103 stations.

There is a uniformly large increase in total traffic on Sundays. The ratio of the average 16-hour week-day total count to the corresponding average 16-hour Sunday count is approximately 1 to 1.7.

The average distribution of Sunday traffic is shown for 16 stations in the following table:

Table showing average 16-hour Sunday traffic at 16 stations.

Type.	Average vehicles.	Per cent of total traffic.	Per cent of total trucks.
Light automobiles	833	36.8	
Heavy automobiles	1,282	56.6	
Busses	29	1.3	
Trucks, class 1	62	2.7	50.5
Trucks, class 2	18	.8	14.6
Trucks, class 3	10	.4	8.1
Trucks, class 4	12	.5	9.7
Horse-drawn vehicles	21	.9	17.1
Extraordinarily heavy			
Total of all vehicles	2,267	100.0	100.0
Total of trucks only	123		

The daily motor-truck traffic throughout the State, as determined by the actual count for equivalent 16-hour days at the 103 official stations, was 12.48 per cent of the total traffic.[19]

The total daily motor-truck miles over the California State highways was then computed separately from the actual traffic count. This daily truck mileage is the total of the areas below the motor-truck curve shown in the traffic diagrams, or 286,375 truck-miles. The result does not apply throughout the year, because the interval of the count, between August 7 and October 14, fell within the limit of the "peak-load" interval on the California highway system for hauling of agricultural products.

This "peak-load" interval for agricultural products was determined separately for a group of 30 counties north of the Tehachapi Mountains and for a group of 8 counties of southern California, all traversed by the State highways. The data were obtained from the report of the State board of equalization for 1918 and from field investigations. The field investigations were made by an engineer and resulted in satisfactory determination of the entire interval of market hauling of 9 separate groups of crops and of the "peak interval." With these separate crop-marketing intervals and the total yields from the report of the board of equalization and from comprehensive road maps for each county it was possible to make a fairly satisfactory estimate both of the "peak interval" and the "peak load" in tons which it is the duty of the California State highways to carry. It was found that apparently about 23 per cent of all agricultural products is hauled for some distance over State highways.

[19] There is found to be considerable truck traffic before 6 a. m. This traffic was, therefore, not included in the standard 16-hour day.

The results are shown plotted in Plate XXXIX for the two portions of the State designated. In this figure is also indicated the interval within which traffic counts occurred. From this diagram it is at once seen that the motor-truck traffic counts were taken during such period of the year that they probably represent more than the average daily market hauling.

TRUCK QUESTIONNAIRES.

A questionnaire was sent out during the month of August to approximately 21,000 owners of trucks with solid tires. From this questionnaire 4,707 replies were received, of which 364 were blank and 1,495 were operating more than 95 per cent within cities. An additional 1,078 could not be used because of defective data. There remained 1,930 replies which could be identified from owners using one or more of the State highways. There follow tables showing answers to various questions in this questionnaire:

Capacity of trucks in tons.	Average distance operated daily.	Average weight cargo (pounds).	Average advantageous speed (miles per hour).	Average mileage per gallon of gas.
½	31.0	1,007	18.0	14.7
¾	29.8	1,462	17.6	11.1
1	44.7	1,963	13.9	11.4
1½	34.0	3,591	15.7	9.5
2	53.9	4,624	14.5	8.6
2½	47.4	5,776	13.2	7.8
3	44.8	6,992	12.6	7.8
3½	47.7	8,353	9.9	5.9
[1] 4	56.6	9,800	11.8	5.1
[2] 5	60.8	10,950	11.1	4.9
[3] 5½	69.0	14,000	12.4	4.1
[4] 6	59.8	14,222	12.8	4.7
[5] 6½	42.5	12,500	12.5	5.5
[6] 7	38.0	13,888	9.6	5.2

[1] From an average of 91 replies.
[2] From an average of 130 replies.
[3] From an average of 5 replies.
[4] From an average of 9 replies.
[5] From an average of 2 replies.
[6] From an average of 7 replies.

The commodities reported as hauled by motor truck in the available answers to the questionnaire are shown in the table below:

What trucks haul—From questionnaires.

FARM TO MARKET.

Class.	Number reporting.	Aggregate load in pounds.
Garden truck	312	1,444,885
Fruits of various kinds	438	1,763,225
Cereals, hay, feed	329	1,729,910
Cotton	2	4,500
Meat and live stock	95	289,950
Dairy products	131	461,128
Poultry and eggs	11	18,800
Honey and bee products	18	45,750
Fuel wood	81	315,850
Totals	1,417	6,073,998

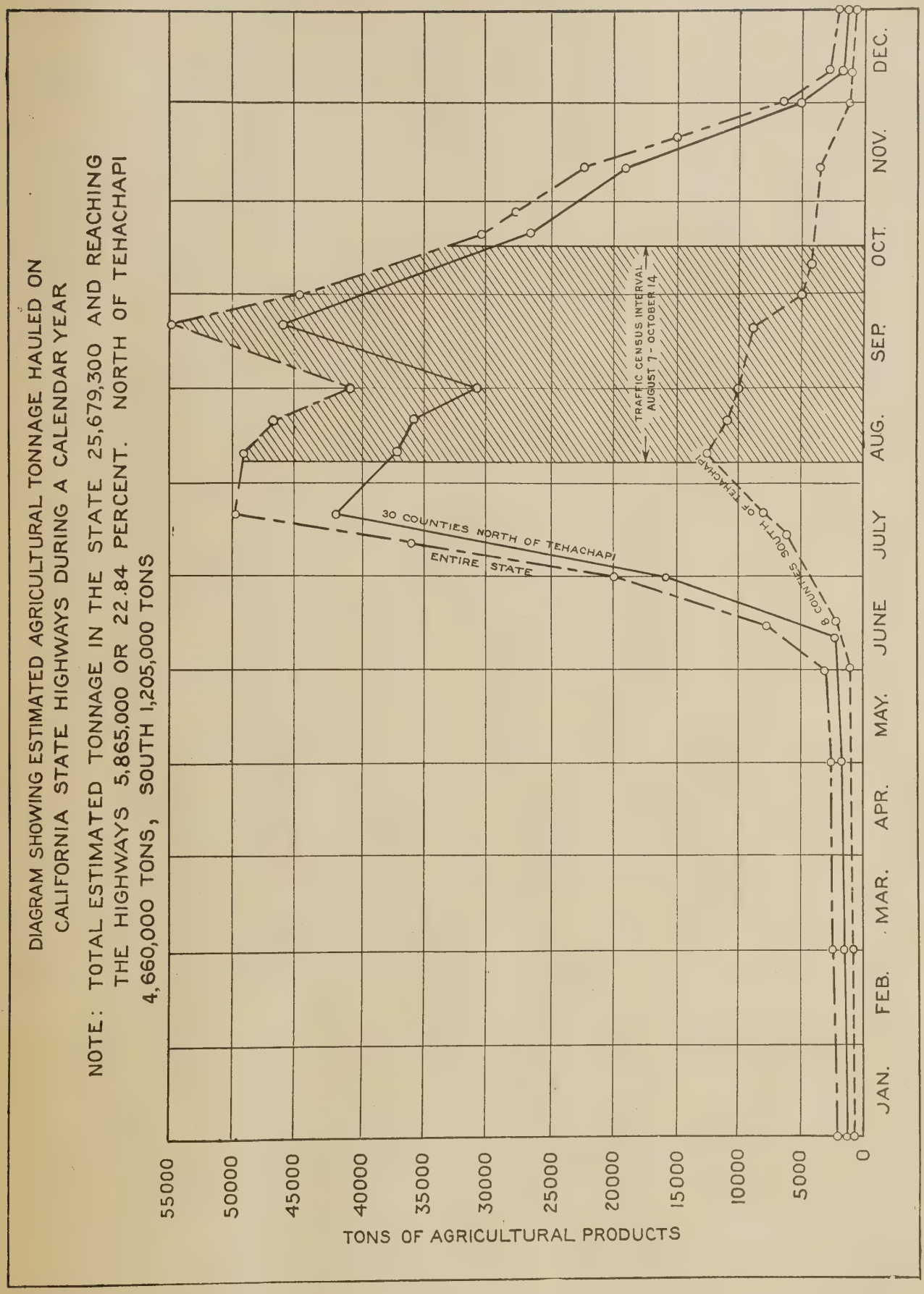
AWAY FROM MARKET.

Groceries, provisions, and general merchandise	187	631,900
Dry goods and laundry	7	10,250
House furnishings	103	267,900
Building materials and machinery of all kinds	500	2,777,150
Seed amd nursery stock	16	46,400
Ice	51	173,700
Soft drinks, etc	44	164,300
Freight	32	107,820
Gasoline and oil	45	211,700
Totals	985	4,391,120

PLATE XXXVIII.

TRAFFIC ON STATE HIGHWAYS.

PLATE XXXIX.



75712—22——7

PLATE XL.

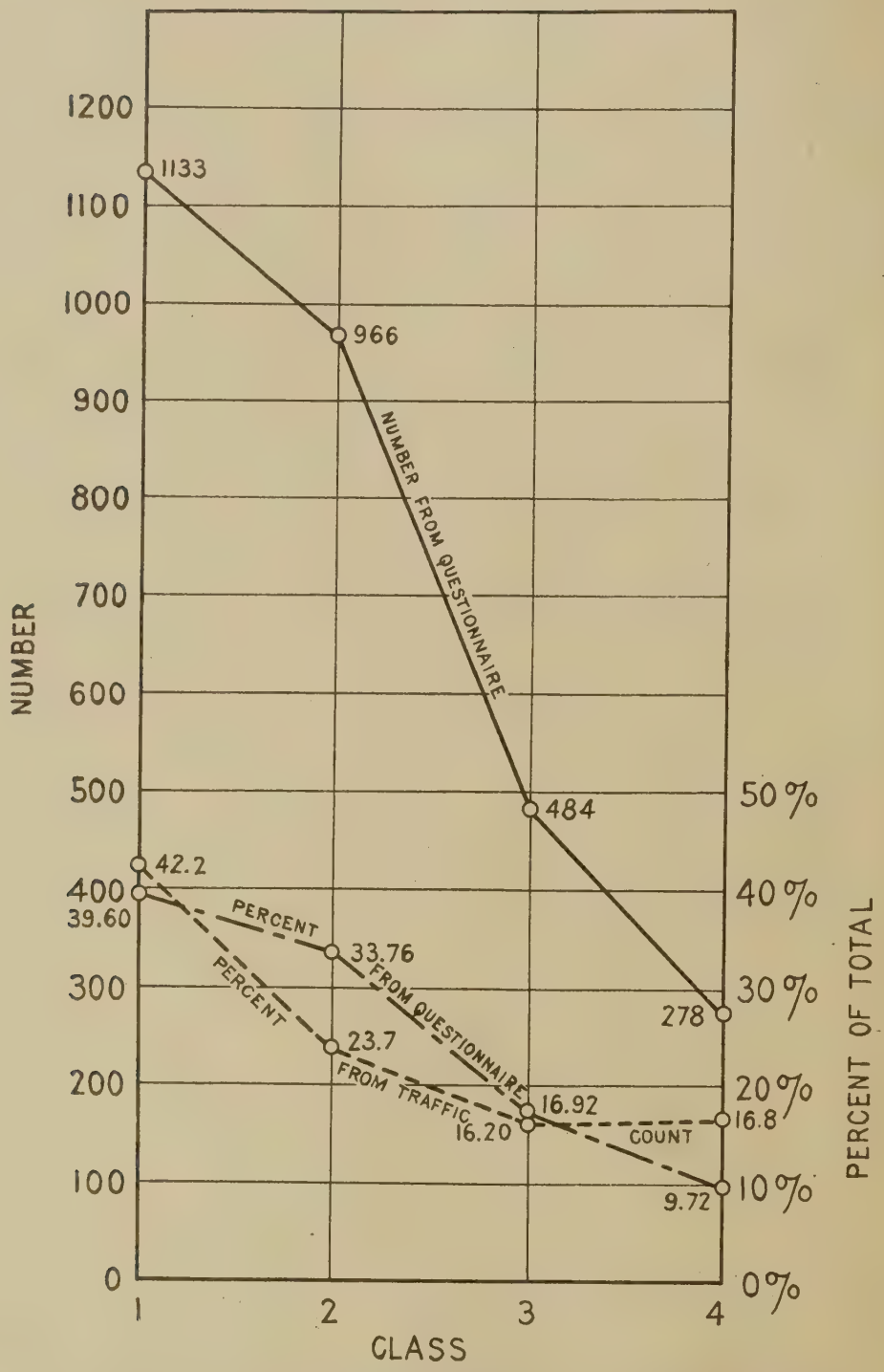


DIAGRAM SHOWING TOTAL NUMBER OF TRUCKS IN FOUR CLASSES REPORTED BY QUESTIONNAIRE AND RELATION OF PERCENT IN EACH CLASS TO CORRESPONDING PERCENT FROM TRAFFIC COUNT.

The data in this table are of little value in respect to information as to the total commodity hauling by motor truck in California, since they are compiled from only 2,402 answers. They probably indicate (*a*) the relative amounts of various commodities hauled, and (*b*) the ratio of inbound to outbound loads, which is 1.44[20]; (*c*) the arithmetic average load of about 2.1 tons; (*d*) the relative number of trucks hauling agricultural products and merchandise, etc.

In order to develop further information on the operation of motor trucks and to gage the effectiveness of the truck questionnaire, there are shown in Plate XL the numbers of the various classes of trucks reported in answer to the questionnaire, together with the relation of the percentage of such trucks in the various classes to the corresponding percentage computed from the traffic census. In each case the classification of trucks is that used in taking the traffic census.

PASSENGER BUS LINES.

Organized automobile stage truck transportation originated in California and promises to develop into a necessary and large public service. Rail and electric transportation systems are vitally interested, and regulatory and control legislative action was early essential.

By legislative act approved May 10, 1917 (amended May 13, 1919), the railroad commission of the State of California was given "the supervision and regulation of the transportation of persons and property for compensation over any public highway by automobiles, jitney busses, auto trucks, stages, and auto stages." Under this law the railroad commission fixes rates, classifications, and rules and regulates the accounts, service, and safety of such transportation companies. This jurisdiction superseded conflicting jurisdiction of any municipal or county authority. Carriers operating over a regular route between fixed termini must secure a permit from municipal authorities through whose territory they operate, provided they were not operating prior to May 1, 1917. Carriers operating other than wholly within the incorporated limits of a city or town must secure a certificate of public convenience and necessity from the railroad commission. Rules and regulations were established by the commission governing fares and rates, time schedules, filing of bonds, and safety of operation of stages and trucks.

The applicant for a permit to operate a stage or truck line, having secured a permit from the municipal authorities, must file a statement setting forth the termini and description of the route; time schedule and fares; description of equipment, list of officials of the company, etc., and names of stage or truck lines, steam railroads, and electric railways operating between the points to be served.

Upon filing of the application, a public hearing is fixed, and the applicant and existing transportation lines affected are asked to present evidence and arguments for and against granting the application. If it is found that public necessity and convenience make the proposed line advisable, and that the applicant is financially able to render the service and otherwise capable, the railroad commission grants permission to operate the line.

The powers of the railroad commission relative to operation of the lines are far-reaching. Reports upon the manner of operation, character of service,[21] assets and liabilities, numbers of persons or tonnage carried, receipts and disbursements, and other related data are required and rules and regulations for operation are issued.

When the original act became effective a number of auto stage and truck lines were actively operating, in most cases with but a single truck, driven by the owner. There was no law specifically regulating State authority and the business was practically without system. Irregularities and abuses were common. The entire auto stage business, and to a somewhat lesser degree, the truck business, has now become stable and systematized. Lines operating under the most favorable conditions, or best able to adapt themselves to the new law, continue to operate under the authority of the commission.

Under the sanction of the State and with the protection accorded against unfair and unnecessary competition business has improved and expanded enormously, and promises to grow with even greater rapidity with the extension and development of the State highways.

A systematic study of these passenger bus and freight truck lines was made with special reference to the use of the State highways. A summary of the passenger bus information is presented in Table 30.

Of the 103 lines 54 have schedules involving two to five round trips per day between termini. The least frequent schedule authorized by the State railroad commission is that of one trip weekly on the line from San Francisco to Portland, Oreg. (786 miles, of which 163 are on the State-paved highway). The most frequent is 54 round trips per day between Los Angeles and Santa Ana, a distance of 36 miles (of which 25 miles is over State highway No. 2).

As far as practicable, bus-line routes or division points on routes are so located that the distance can be covered in not to exceed one day. In 47 per cent of the

[20] Not restricted to any given time or part of year in the questionnaire.

[21] Deviation from schedule is not permitted.

routes this distance ranges from 25 to 99 miles, which permits one or more round trips per day. The average length for the 103 lines is 59 miles.

A large number of the companies cooperate to make practicable the purchase of through transportation over connecting lines. The longest through trip possible by such arrangement is that from El Centro via San Diego, Los Angeles and San Francisco to Portland, Oreg., a distance of 1,488 miles.

There is a tendency to combine ticket offices and establish common starting places or union stations at Oakland, Los Angeles, Fresno, Bakersfield, etc.

Plate XLI shows pictures indicative of the passenger motor-bus business.

TABLE 30.—*Summary of bus-line data—lines in whole or in part traversing State highways.*

State highway route No.	Number of bus lines operated.	Total distance between termini.	Total miles paved State highway between termini.	Number of trips each way between termini daily.	Car-miles between termini daily.[1]	Car-miles on paved State highway.[1]	Number of through passengers daily.[2]	Passenger-miles between termini.	Passenger-miles on paved State highway.
1 [3]	1	99.25	31.3	6	199.5	187.8	(4)	(4)	(4)
	3	67.25	49.7	22	784.5	607.5	484	23,746	18,901
2	3	41	32.5	58	477	377	(4)	(4)	(4)
	30	1,918	1,217.75	(4)	31,860.5	22,960.5	9,342.25	519,649	389,103
3	3	36.75	21	73	778.5	435	700	7,635	4,260
4 [1]	1	12.75	12.5	4	51	50	(4)	(4)	(4)
	16	607.75	347.75	214	10,370	7,632	2,009	90,504	64,761
5	7	278.75	176.75	140	5,637	9,883	1,310	62,178.5	43,716.5
6	1	14.25	14.25	6	85.5	85.5	24	342	342
7	2	926	180.5	2.14	207	57	9	1,206	299.5
8	1	36	6.5	6	216	39	12	432	78
9	4	171.25	123.75	82	3,789.5	3,135.5	1,027	50,456.25	44,794.25
10	1	60.75	8	4	243	32	24	1,458	192
11	3	82	72	22	651	574	208	4,890	4,273
12	1	5	5	12	60	60	(4)	(4)	(4)
	6	498.25	271.75	22	1,907	1,025	136	12,179	6,500
14	3	36.5	25	3	476	430	(4)	(4)	(4)
	6	168	86	159	2,159.2	1,538.4	908	20,231	10,608
18	1	93	15	2	186	30	70	6,510	1,050
22	1	172	7	2	344	14	12	2,064	84
26	1	193	5	.85	165	4.28	6	1,158	30
Combinations of 15 of above routes	1	14	11	8	112	88	(4)	(4)	(4)
Do	7	608.75	355.5	52	4,461.5	2,801.5	383	33,230	21,755
Total	[3] 103	6,074	3,075	900	65,220	46,046	16,664	837,869	610,747

[1] One line from Fresno to Bakersfield not included (total distance, 109¼ miles—paved State highway, 106½ miles); record lost in mail. In this summary table one car per scheduled trip is taken as the basis for car-mile calculations, but on many runs two or more busses are regularly dispatched and as many as 10 on special occasions. Flexibility of service is one of the main claims of the motor-stage operators.

[2] Estimated average number through passengers; local passengers estimated as 15 per cent of through traffic.

[3] Three lines out of Eureka not included for want of data (total miles, 25; paved State highway, 18½ miles).

[4] Incomplete.

Below are given three additional tables of data regarding the passenger motor-bus business.

Daily trips between termini.

Number of trips daily.	Number of lines operating.
2 or less	15
3 to 10	54
11 to 20	12
21 to 40	14
41 to 60	4
61 to 80	2
80 or more	2
Total	103

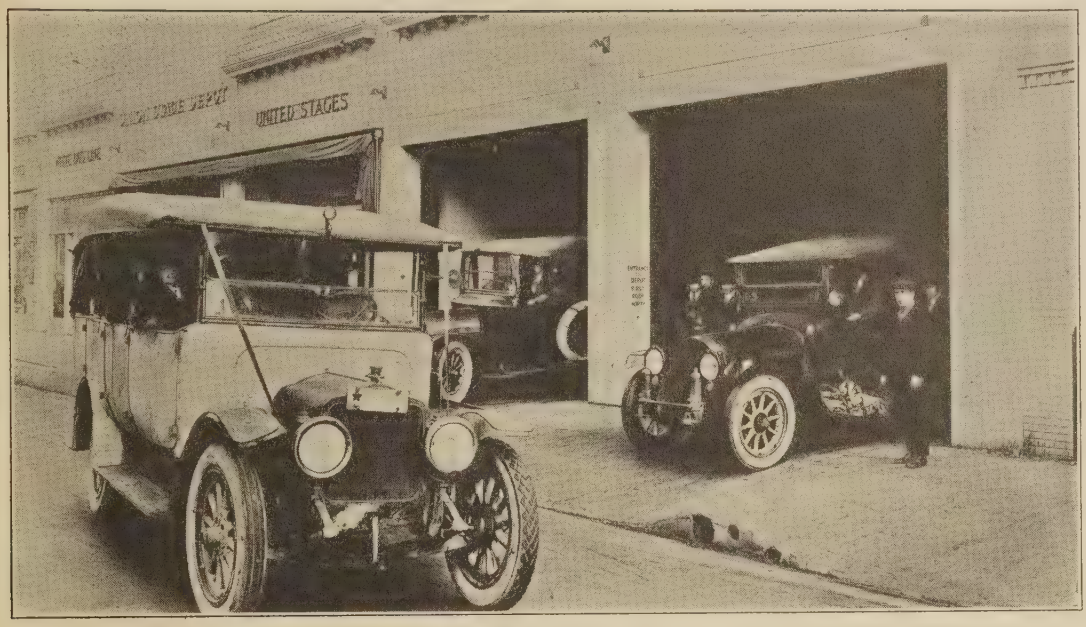
Number of bus lines of various length.

Length in miles.	Number of lines operating.
0 to 4	8
5 to 9	15
10 to 14	11
15 to 24	14
25 to 49	26
50 to 99	22
100 to 199	3
200	1
Total	103

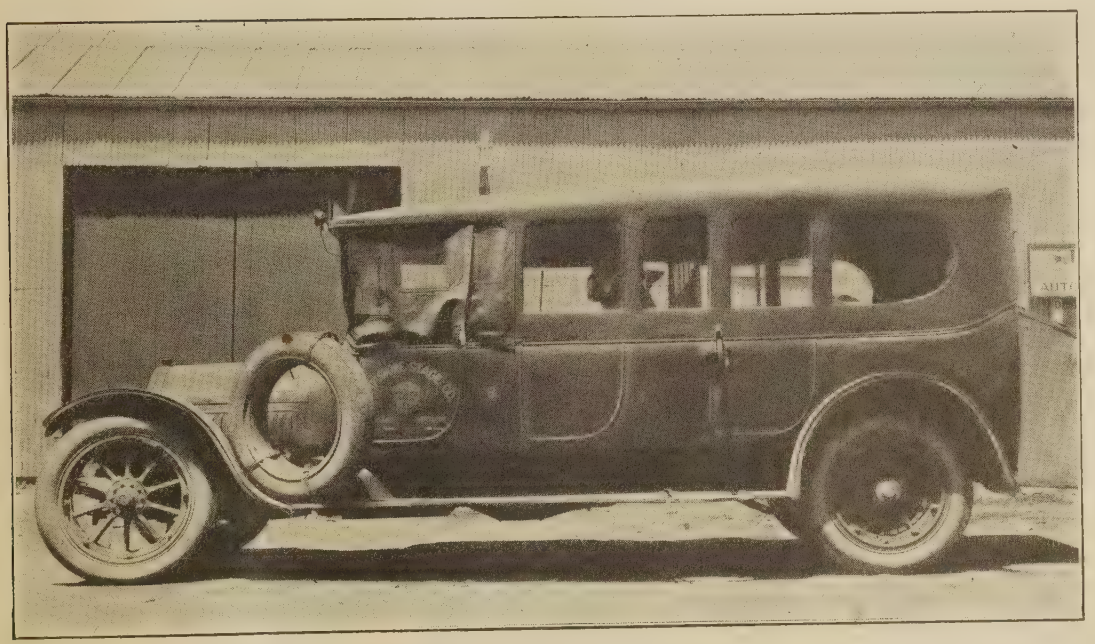
Passenger capacity of equipment, scheduled trips, etc., of some of the larger bus-line companies.

Number of cars.	Passenger capacity.	Total capacity.	Daily trips each way.	Distance between termini.	Termini.	Highway route No.
				Miles.		
40	18	720	62	36	Los Angeles–Santa Ana	2
38	14-22	674	108	36	do	2
27	23	621	102	31	San Francisco–Palo Alto	2
4	22	616	32	67.75	Los Angeles–Redlands	9
12	16					
24	14					
1	23	378	48	43	Oakland–San Jose	5
10	19					
5	15					
6	11					
3	8					
1	8	195	26	77.5	Stockton–Oakland	5
3	11					
2	14					
7	18					
13	15	195	52	117.5	Sacramento–Merced	4
4	22	186	36	23	San Fernando–Los Angeles	9
7	14					
17	8-11	170	10	127.5	Los Angeles–Bakersfield	4
20	8	160	6	134.5	San Diego–Los Angeles	2
20	8	160	6	134.5	Los Angeles–San Diego	2
5	18	118	14	52.25	Santa Rosa–Sausalito	1
2	14					
16	7	112	2	93	Merced–Yosemite	18
1	19	102	6	51.5	Sacramento–Placerville	11
2	14					
5	11					

PLATE XLI.



AUTO STAGE DEPOT, LOS ANGELES.



SAN FRANCISCO—MARTINEZ STAGE.

MOTOR TRUCK FREIGHT LINES.

A special investigation was made of the motor truck freight lines licensed under the State railroad commission and as one result there is presented Plate XLII, which shows the reported number of motor trucks of the several existing classes as returned by this investigation and also as determined by replies to the questionnaire to all owners of solid-tired trucks. Additional commercial motor-truck traffic information is shown in Appendix F.

FIELD WEIGHING.

In addition to the above indicated studies, 219 motor vehicles (and 5 horse-drawn vehicles) were weighed in the field as shown by the following table:

Weighing data.

Place.	Date.	Number of vehicles.
Gilroy	Sept. 25, 27, 1920	86
French Camp	Sept. 29, 1920	46
Modesto	Sept. 30, 1920	40
Yuba City	Oct. 2, 1920	24
Santa Rita	Oct. 4, 5, 1920	28
Total		224

The results of the weighing are shown below. The truck capacities there indicated conform to the classification used in the field traffic counts since no heavy pneumatic-tired trucks came to the scales.

Summary of result of field weighing.

Kind of vehicle.	Number.	Average gross weight in pounds.
Light autos, motor cycles, Ford, Chevrolet, Saxon, Dodge, and like runabouts	13	1,924
Heavy autos, all autos heavier than those classed as light	23	3,828
Miscellaneous trucks, empty	4	.....
Trucks, less than ¾-ton capacity	14	2,091
Trucks, ¾ to 1½ tons capacity	42	4,708
Trucks, 2 to 3 tons capacity	44	10,034
Trucks, 3 tons or greater capacity	33	14,640
Trailers	33	4,863
Busses	12	7,461
Horse-drawn	6	5,838
Tractors	1	6,290
Total	225	.....

SPEED MEASUREMENT.

Measurement of speed of motor vehicles was made in the field with measured distance and stop watches at four stations, as follows: Modesto, Gilroy, Saugus, Richmond. These stations were chosen from the traffic count and where total travel was not excessive.

The results of this study with respect to speed of the various classes of vehicles are shown in the following table:

Speed of motor vehicles.

Type.[1]	Miles per hour.	Number observed.
Light autos	24.3	990
Heavy autos	26.1	1,177
Busses	29.7	113
Trucks, class 1	23.2	153
Trucks, class 2	19.9	61
Trucks, class 3	16.5	41
Trucks, class 4	13.7	83

[1] The classes of trucks refer respectively to those adopted in the traffic census.

GENERAL.

There was found to be a certain typical hourly variation throughout the 16-hour day in all traffic throughout the State. This average hourly variation in per cent of total daily traffic for a week day as determined from 111 week-day counts, taken at 101 stations, is shown in Plate XLIII, together with the corresponding hourly variation of Sunday total traffic from 56 partial and complete Sunday counts at 37 stations.

The corresponding hourly variation in truck traffic only is similarly shown for a week day in Plate XLIV. This curve indicated a considerable truck traffic before 6 a. m. The figure of 12.48 per cent for total truck traffic is, therefore, subject to a plus correction, as the percentage of total traffic prior to 6 a. m. is much less than that of trucks.

There is shown in Plate XLV the typical average variation of total traffic during an entire week based on all counts taken. In Plates XLVI and XLVII are shown respectively the relative decrease of horse-drawn traffic and the relative increase in motor-truck traffic as determined from traffic counts in Kern and Los Angeles Counties.

A summary of various truck data from various sources is shown in Table 31.

TABLE 31.—*Summary table showing truck traffic data.*

[From traffic census, field weighings, and questionnaire.]

Class of trucks.	From traffic census.		Weighted average speed, miles per hour.		Weighted average weight from field weighings in pounds.			Average cargo weight, in pounds.		Average length of haul, in miles.	
	Weighted daily average number of trucks.	Per cent of total daily vehicles.	From speed count.	From questionnaire.	Front.	Rear.	Total.	Field weighings.	Questionnaire.[2]	Field.[1]	Weighted average, questionnaire.[2]
Less than 1-ton pneumatics, less than ¾-ton solid	73	5.3	23.2	18	697	1,394	2,091	([3])	1,007	14	31
1 to 2½ ton pneumatics, ¾ to 1½ ton solid	41	3.0	19.9	14.7	1,674	3,034	4,708	1,684	2,332	43.7	39.1
3 to 5 ton pneumatics, 2 to 3 ton solid	28	2.0	16.5	14.1	3,227	6,807	10,034	4,649	5,970	48.6	51
5-ton-plus pneumatics, 3-ton-plus solid	29	2.1	13.7	110.8	4,751	9,889	14,640	6,989	9,603	73.5	[4] 54.4
Extra heavy	2	0.1	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	178	12.5	.....	.....	.....	.....	.....	.....	.....	.....	.....
Weighted average	.....	.....	19.4	14.0	2,848	5,810	8,658	3,682	4,324	48.6	45.3

[1] From replies to questions at the 138 weighings at 5 stations.
[2] From 2,766 replies to 21,000 inquiries.
[3] Styles of body too variable to permit accurate estimate of weight of trucks. Weights of all other trucks determined from manufacturers' catalogues.
[4] Twenty trucks of this class and above 5 tons' capacity were reported by the questionnaire, but the data is not included in this figure.

PLATE XLII.

DIAGRAM SHOWING COMPARISON OF NUMBER OF TRUCKS OF VARIOUS CAPACITIES REPORTED ON QUESTIONNAIRES AND BY LICENSED FREIGHT LINES.

PLATE XLIII.

DIAGRAM
SHOWING
AVERAGE HOURLY VARIATION OF WEEKDAY TRAFFIC AT 101 STATIONS
AND CORRESPONDING AVERAGE HOURLY VARIATION OF SUNDAY TRAFFIC AT 37 STATIONS

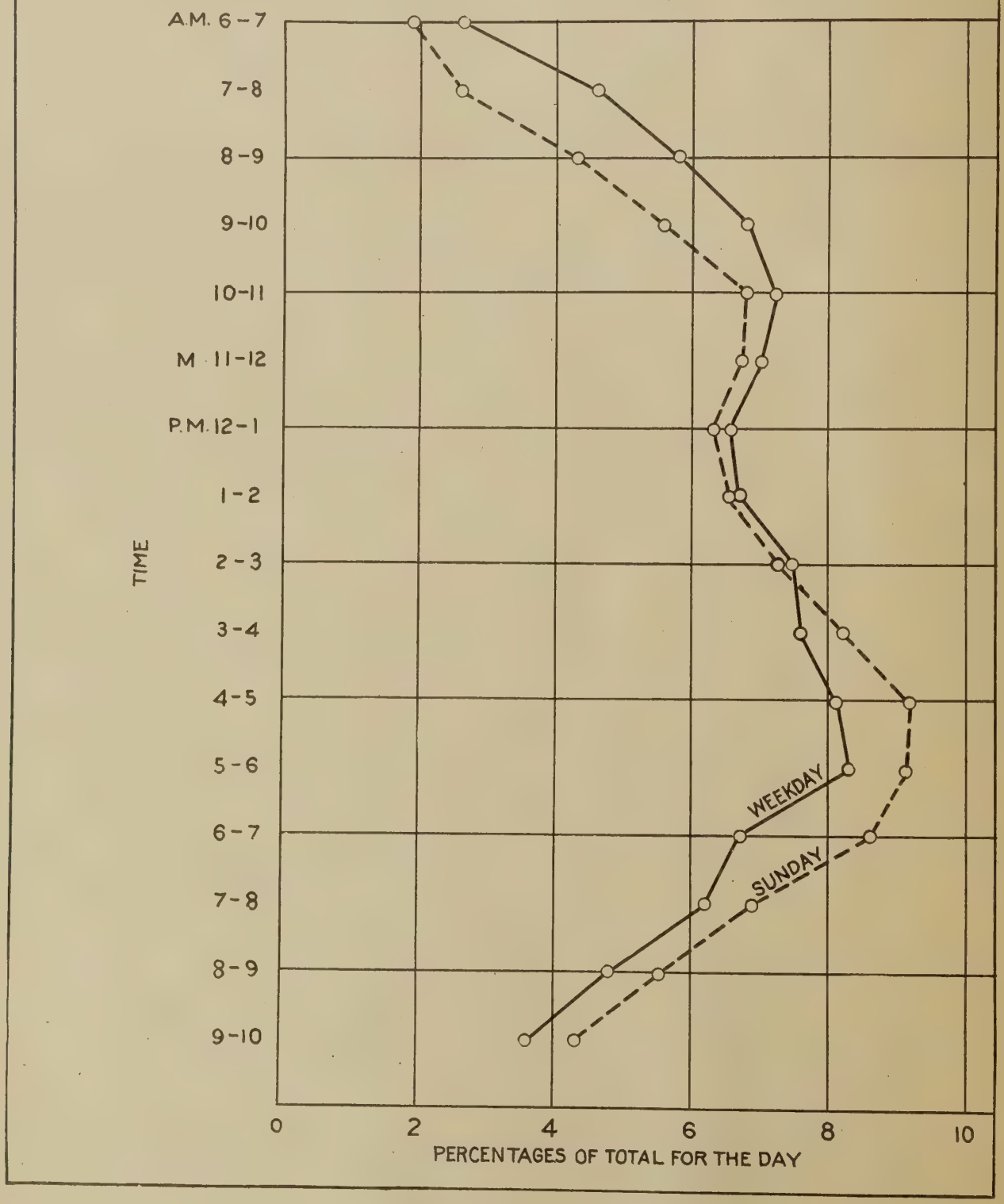


PLATE XLIV.

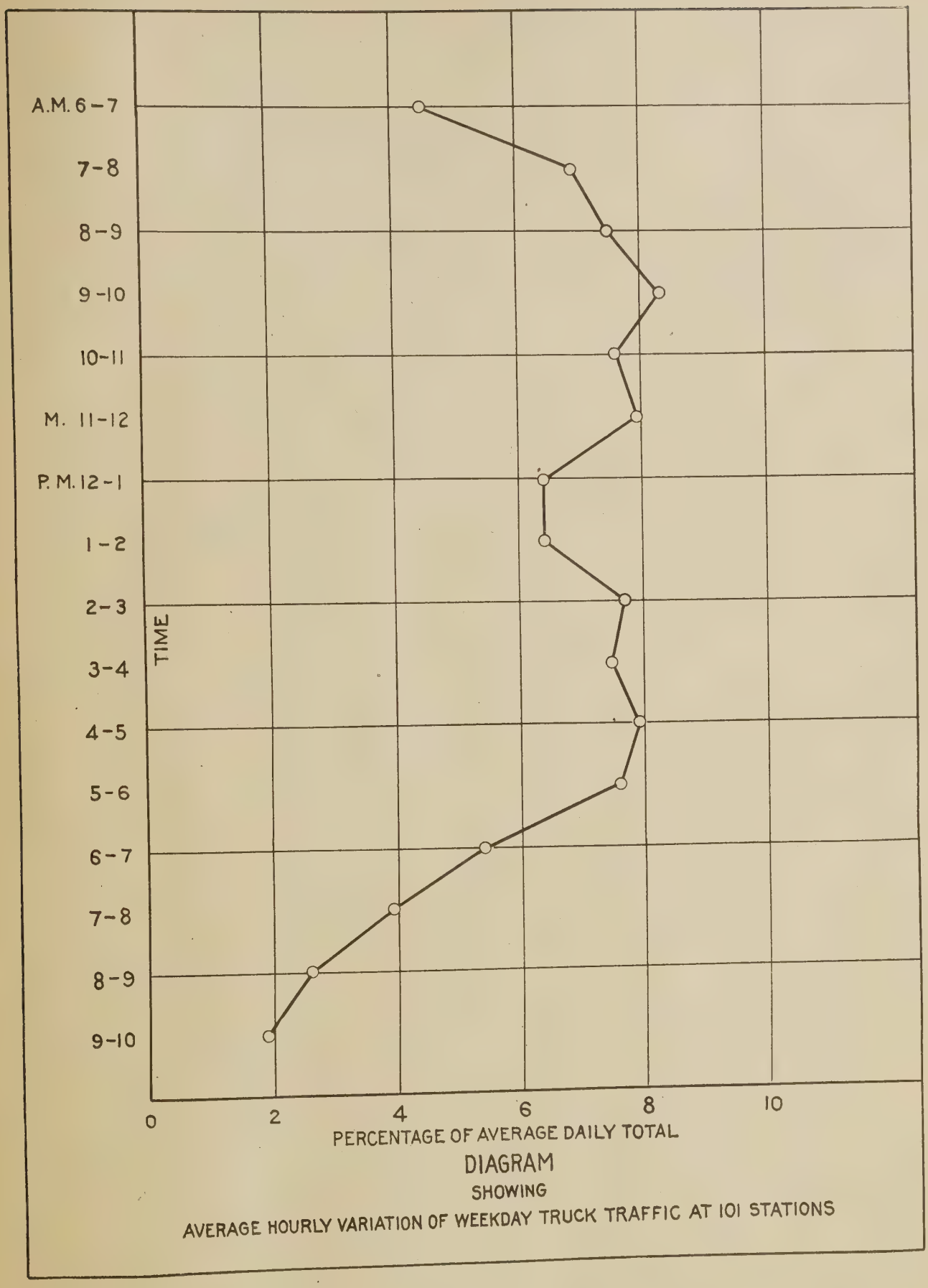


DIAGRAM
SHOWING
AVERAGE HOURLY VARIATION OF WEEKDAY TRUCK TRAFFIC AT 101 STATIONS

PLATE XLV.

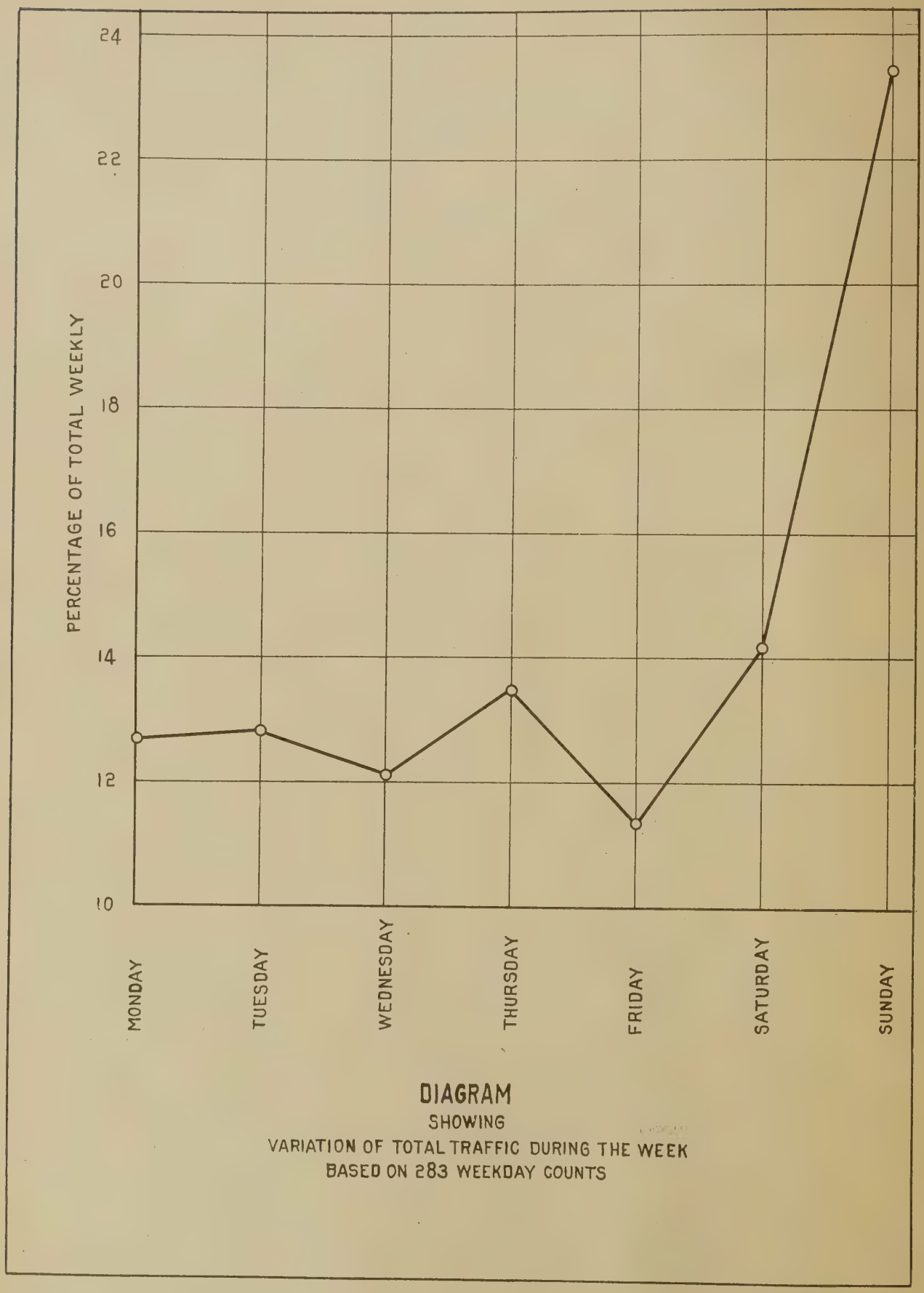


DIAGRAM
SHOWING
VARIATION OF TOTAL TRAFFIC DURING THE WEEK
BASED ON 283 WEEKDAY COUNTS

PLATE XLVI.

KERN COUNTY

AVERAGE NUMBER OF TRUCKS AND HORSE DRAWN VEHICLES
PASSING FIVE STATIONS

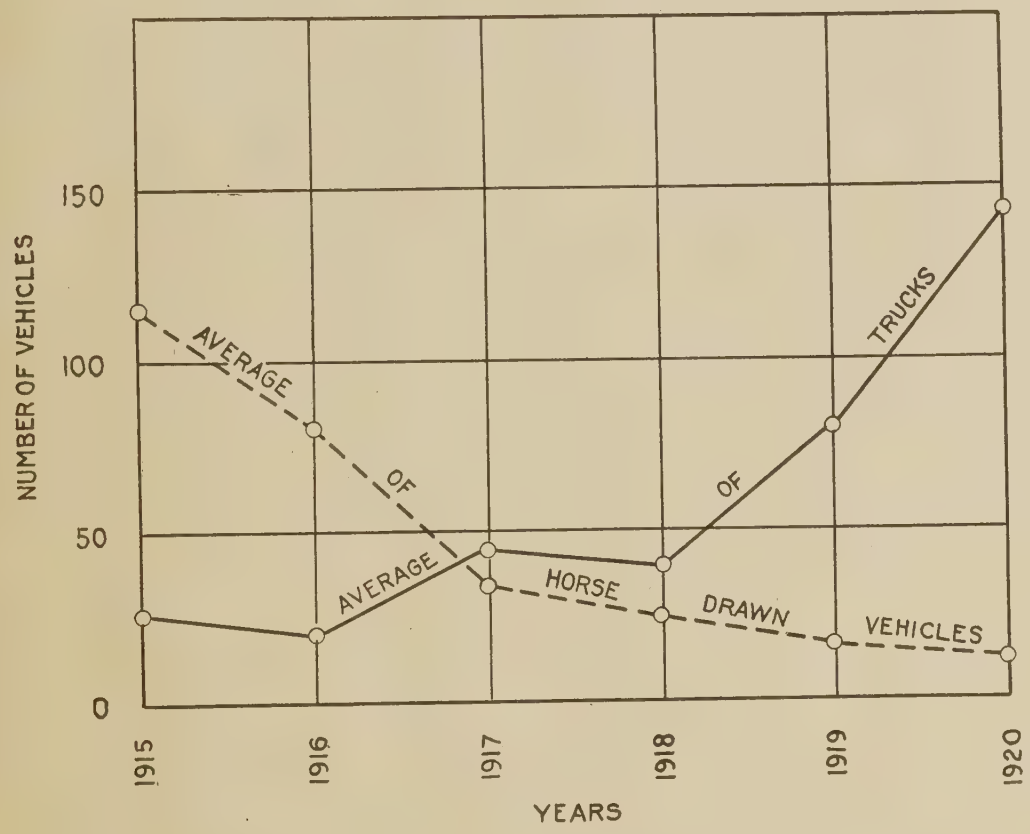
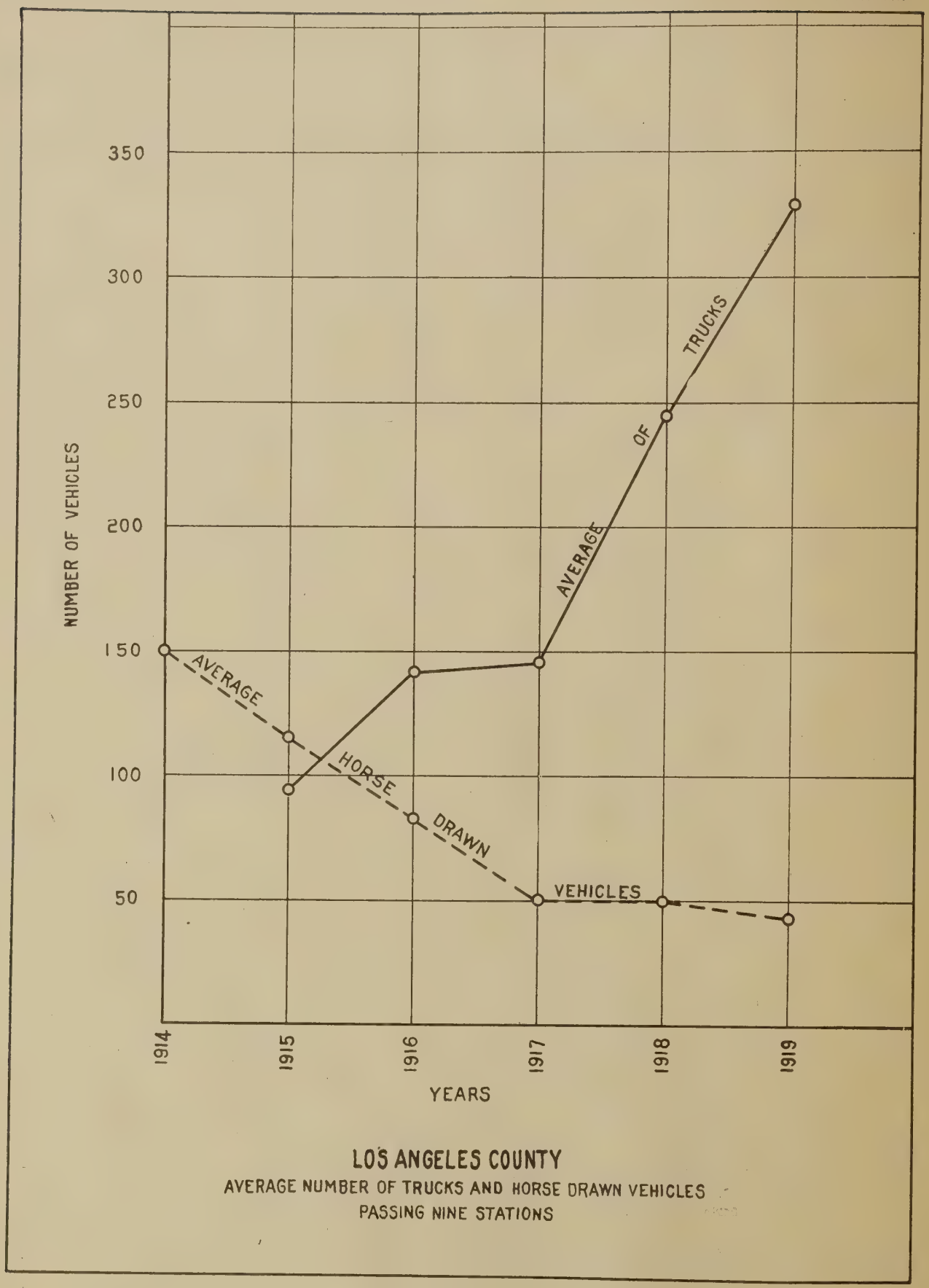


PLATE XLVII.



LOS ANGELES COUNTY

AVERAGE NUMBER OF TRUCKS AND HORSE DRAWN VEHICLES PASSING NINE STATIONS

VIOLATIONS OF STATE LAW.

In connection with truck traffic the State highway commission states in the first biennial report:

The present State highways are being subjected to constant abuse by too heavily loaded trucks and other agencies.

The statute books of California already contain sufficient legislation to regulate and penalize these violations, but the delinquency lies in the enforcement of these laws.

The commission is of the opinion that the most effective policing of these evils will result from the establishment of a State motor police limited both in numbers and authority under the jurisdiction of the motor vehicle department, who could apprehend both motor vehicle offenders and persons injuring the improved highways of the State.

The chief engineer states in the same report—

that in the northern part of the Sacramento Valley a new difficulty presents itself in the rapidly increasing use of the land for rice culture. * * * In November and December of this year (1918) the State highway has been damaged seriously by motor trucks hauling rice. All the trucks carry loads in excess of their rated capacity, and it is probable that in all such cases the loading on the rear wheels per inch of width of tire in contact with the pavement is in excess of the limit of 800 pounds fixed by the motor vehicle act. It would be folly to direct or discourage all trucks and tractors, but they should conform to the legal requirements of the vehicle act, which are reasonable and were enacted in 1917 at the suggestion of the Motor Truck Dealers' Association. If such excessive loads are to be permitted the State must spend much money to strengthen the roads, and why should such selfishness be permitted? Why should not the reasonable provisions of the vehicle act be enforced?

The inspection force of the motor vehicle department is composed of nine men working under the direct supervision of one chief. Each man is assigned to a particular district, and the secretary of the motor vehicle department reports that it is impossible for these men to enforce all the provisions of the motor vehicle act. Their paramount duty is the collection of license fees. The enforcement of the law regarding weight limit and speed limits has been left almost entirely to the local officers throughout the State. The State officers work in conjunction with the local police, and where a case arises the traffic officer of the district is called upon to do the prosecuting. Violations of the motor vehicle act or convictions that are carried to the court are reported to the motor vehicle department. The abstract of the court records so filed from July 22, 1919, to October 18, 1920, shows a total of 33 convictions of violations of the law; with respect to flanges (4), weight per inch width (19), number of trailers (2), special permits (3), and with respect to unspecified provision of the section governing all these points (5). The fines range from $100 for flanges to $4 for operation without special permit, and in the case of excess weight per inch of width from $50 to $10.

DISCUSSION

BOND ISSUES, SYSTEMS DESIGNED, AND GENERAL POLICY.

The system of 4,500 miles laid out in 1896 by the old State bureau of highways reached every county seat and traversed the main valleys. It was doubtless of value as a guide to the selection of the system of 5,560 miles now building, and the present system visibly reflects the original one.

Apparently the interval from 1896 to 1909 demonstrated the futility of attempting to create an adequate system of State highways by small special appropriations for selected roads.

The State highway bond issue of 1909–10 had been preceded by an issue of $1,250,000 in San Diego County and of $3,500,000 in Los Angeles County and by highway-bond issues in Eastern States. The deferred serial type of bond chosen was in accord with the best practice, but the term of 45 years for the longest serial is unnecessary and will require a corresponding excessive total interest payment. The legal provisions fixing both the nominal interest and the sales price proved embarrassing to the highway commission. There is every evidence that the bonding principle itself at this period was sound.

The highways act of 1909 created by implication a system of 3,082 miles, which was manifestly far in excess of the possible construction with the fund of $18,000,000 provided. The influence of this discrepancy has been far-reaching. The State highway commission stated in their final report: "Notwithstanding the admittedly impossible task, the commission endeavored by the employment of every honorable expedient to obtain the greatest possible return in roads for the money."[22]

Actually 1,300 miles, including graded roads, were built from proceeds of the first bond issue.

The system of roads laid out under and by the various laws is an excellent one, and the portions built by the commission prior to January, 1917 (when the funds of the first bond issue were exhausted), appear in general to have been most needed. The distribution and the order of this first construction may have been conditioned by necessary policy. Because of the legal restriction on the sale of bonds, it became necessary for various counties to buy the bonds, and naturally roads in those counties which bought took some precedence. Counties were also obliged to pay the interest charges on the funds used for highways within their boundaries—some of the poorer counties were not easily able to do this. In order to make the bond money go as far as possible, the commission also influenced the various counties to furnish the necessary expensive bridges and rights of way, which action created some opportunity for preference in construction. In addition to these influences, which conditioned the distribution of construction, it was doubtless good policy to acquaint as many voters as possible with the proof of the advantages of improved roads by actual examples. The maps, Plates V to XII, show the progress of construction from year to year.[23]

The success of the initial policy of the commission with respect to type of road and distribution of construction is evidenced by the increased majority for the second bond issue of 1915, and the still larger majority for the third issue of 1919 is evidence of its continued success.

The general policy of the commission, especially with respect to the order of construction, in attempting to carry out the terms of the laws which conditioned the sale of bonds and implied or prescribed excessive mileage to be built, must be judged by its progressive reaction on the whole State rather than by comparing it with other alternative policies that may now be apparent to a State community enlightened by the benefits of the improved roads. Such a possible alternative policy, for example, might have given priority to the trunk road from Los Angeles to San Francisco.

MANAGEMENT.

The actual construction work of the commission was also conditioned by the highway act: (*a*) In respect to its permanent character and (*b*) by the first implied order for more than three thousand miles of highway.

The commission obviously attempted to combine the element of durability in design with rapid extension of mileage. Although the money was theoretically available after the fall election of 1910, no construction was started until August, 1912. There were also theoretically sufficient funds to allow large planning of the work, and the commission took advantage of the opportunity to conduct business on a big scale. They began work deliberately.

In the fall of 1911, with the highway engineer, they made a comprehensive tour of the State and estab-

[22] First biennial report of the California Highway Commission, Dec. 31, 1918, p. 40.

[23] Nearly all the gaps in the 1920 map indicate pavement acquired from the counties.

lished seven divisions. On the 21st of October, 1912, they signed contracts with the Natomas Consolidated of California (a corporation) for 500,000 tons of crushed cobbles at 45 cents per ton, f. o. b., and also contracts with the Russian River Gravel Co. and the Grant Gravel Co. for 175,000 tons of screened gravel at 27½ cents per ton, f. o. b. These were low figures for concrete aggregates, and the commission states they "tended to fix a low price which had its influence on other producers of concrete aggregates." [24]

Effective on October 30, 1912, the commission secured from the Southern Pacific Railroad Co. a local freight tariff for commodities "consigned to and for use by the California Highway Commission" at substantially one-half the prevailing rates. These rates were extended by tariff No. 742–C one year later.

In the purchase of cement the commission states: [24]

> Under unwritten agreement the companies agreed with the commission that during the life of the work the price should not exceed $1.40 per barrel at the mills. This special price, far below the general market price, was made to encourage the use of cement in highway construction.

The actual yearly purchases of cement to July 1, 1920, with net prices, are tabulated below:

Year.	Barrels purchased.	Average mill base.	Cost at mill.
1912	142,465.50	$1.240	$176,683.24
1913	242,514.40	1.309	217,376.36
1914	677,790.25	1.325	898,403.48
1915	355,005.50	1.367	485,267.31
1916	110,090.00	1.371	150,958.28
1917	220,794.00	1.454	321,064.61
1918	221,418.00	1.621	359,036.76
1919	231,737.00	2.038	451,270.72
1920 (up to July 1)	43,048.00	2.158	89,699.56
Totals and average	2,244,862.75	1.443	3,249,780.32

After the first bond issue of $18,000,000 was exhausted, the cement companies felt that their obligation should end.

When the railroads came under national jurisdiction during the war the preferential freight rates were abolished. On account of difficulty of delivery due to war conditions, which resulted in (valid) claims by the contractor and required stock piling at times, and due to the general rise in prices the Commission has temporarily discontinued to supply materials. They state that during the war the work progressed with increasing difficulty due to high costs, open-top car embargo, lack of bidders, restriction of the Capital Issues Committee and the United States Highway Council, but did not stop. The totals of administration, engineering, and other overhead costs have been presented in the section "Data" under the item "Work done" and are very reasonable with the possible exception of the total overhead on maintenance.

[24] First biennial report, p. 39.

STANDARD PAVEMENT DESIGN.

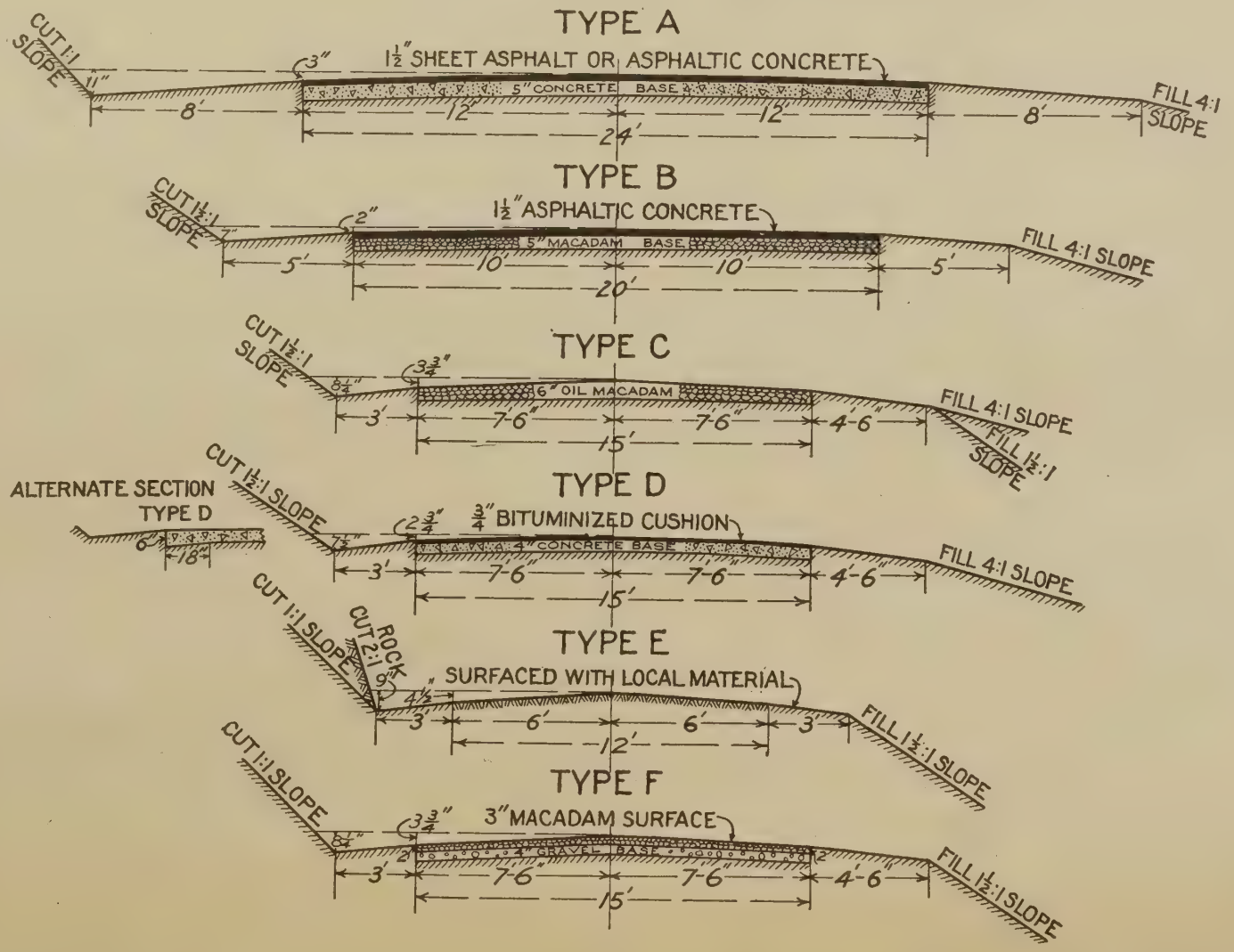
The standard design adopted for surface was a concrete "base" of 4 inches with a three-eighths-inch wearing surface of asphaltic oil and pebbles. The concrete mix was 1:2½:5 and the width was 15 feet, with 3-foot earth shoulders, as shown in Plate XLVIII and XLIX, type D.

Although the concrete surface was doubtless originally laid as a base, only about 43 per cent has been given the oil surface. The average price in the earlier years for the 4-inch, 1:2½:5 concrete including grading and structures was $1.14 per square yard which was remarkably low. This price was equivalent to about $10,000 per mile of completed 15-foot road and compared very favorably with the similar price of $1.21 per square yard for oil macadam. Neither price includes either indirect charges or overhead. The corresponding average price for the 4-inch, 1:2:4 concrete laid since 1917 has been $1.84, which is also low. The concrete pavement has probably produced a smoother and more satisfactory riding surface than any of the other types incidentally laid.

This concrete pavement is the thinnest that has been extensively laid in any State, and would have been rejected as too thin in any State subject to winter frosts. It is one foot narrower than the minimum width of concrete roads built in most other States, and it is believed that under present conditions it is in general 3 feet too narrow. The original mix of 1:2½:5 was leaner than that extensively used in other States and the present mix of 1:2:4 is not as rich as that used in several States, but it is believed to be adequate for the traffic. In this connection it is to be observed that California was the pioneer State in adopting concrete as the standard pavement for the State highway system.

The function of the three-eighth inch asphaltic-oil wearing surface or "skin top" has not been completely determined. That it is not a necessary element of construction is evident from a comparison of the service and condition of bare and covered concrete which now exists. It was probably considered that the asphaltic-oil top would (*a*) take the wear of travel from the concrete, (*b*) protect the concrete base to some extent from impact, and (*c*) prevent the penetration of water through such cracks as occurred. It has not been observed that the bare concrete itself shows evidence of wear by rubber-tired traffic, which almost exclusively is now the only kind of traffic to be found throughout California. Trucks with solid tires, however, cause disintegration at open cracks. It is doubtful if a three-eighth-inch bituminous layer materially lessens impact. A comparison of the data presented in the tables of classification and in the summary class diagrams will show that the condition of the pavement covered with

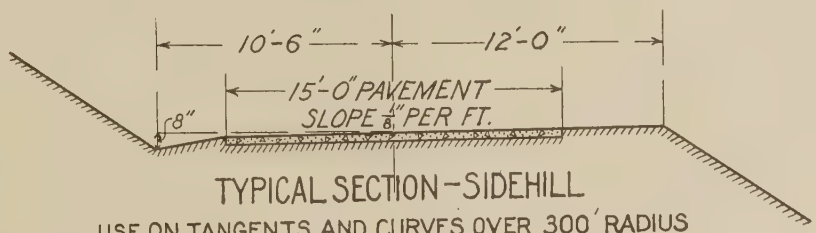
TYPICAL SECTIONS



NOTE.

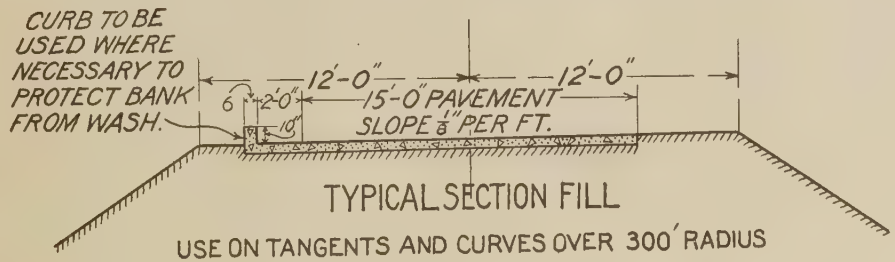
THE THICKNESS OF PAVEMENT SHOWN IS THE MINIMUM
IF ORDERED BY THE HIGHWAY ENGINEER IT IS INCREASED

PLATE XLIX.



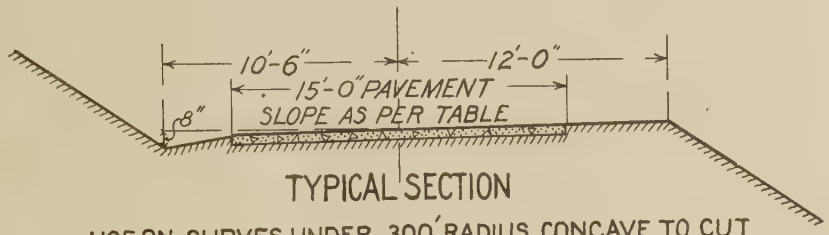
TYPICAL SECTION – SIDEHILL

USE ON TANGENTS AND CURVES OVER 300' RADIUS



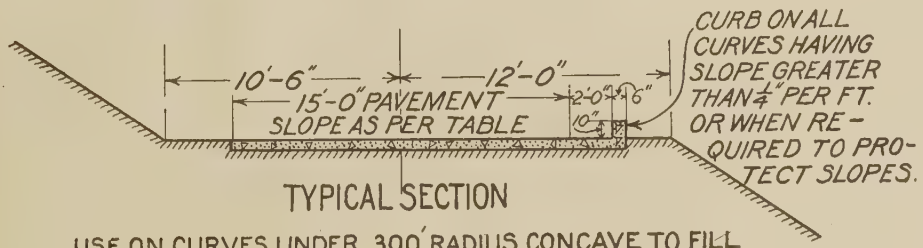
TYPICAL SECTION FILL

USE ON TANGENTS AND CURVES OVER 300' RADIUS



TYPICAL SECTION

USE ON CURVES UNDER 300' RADIUS CONCAVE TO CUT



TYPICAL SECTION

USE ON CURVES UNDER 300' RADIUS CONCAVE TO FILL

TABLE OF CROSS SLOPES

RADIUS OF CURVE	SLOPE
50' TO 75'	3/4" PER FT.
75' " 100'	1/2" "
100' " 150'	3/8" "
150' " 225'	1/4" "
225' " 300'	1/8" "

TYPICAL ROAD SECTIONS

asphaltic-oil top compares favorably with the bare concrete, but it is to be noted that because of the presence of the asphaltic-oil top the classification of the concrete base beneath was made difficult and, in all probability, was higher than it would have been had the concrete base been uncovered throughout. To some extent the asphaltic top has sealed the concrete from water during the rainy periods and thus prevented softening of the subgrade, which is important. It has cost about 8 to 9 cents per square yard and requires considerable repair and renewal and, under nonabrasive, rubber-tired traffic, it is doubtful if it serves a purpose commensurate with its cost, but more study of the extent of subgrade moisture protection is desirable. It is more slippery in wet weather than is bare concrete.

The 4-inch plain concrete of lean mix has proved in places very durable. There are 580 (distributed) miles built prior to 1917 that are of classes A and B. Under adverse conditions, particularly of soil, it is evident, however, that a pavement of such thinness has a very low safety factor and is inadequate. Its use has now been abandoned and a minimum thickness of 5 inches of reinforced concrete is required.[25] The original construction produced considerable rough-surfaced concrete, which, as traffic developed, doubtless materially increased impact. On the narrow 15-foot pavement, loads passing each other necessarily traveled close to the edge. The "crow foot" defects are doubtless due to such travel of trucks whenever the conditions were unfavorable. There is little, if any, decisive evidence that reinforcing introduced in the 4 or even in the 5-inch concrete (particularly of the triangular-mesh variety, see Plate LIII) has proved effective on adverse soils or under combinations of adverse subgrade and traffic. Nor will the widening of a 4-inch pavement to 20 feet eliminate the "crowfoot" cracks which are observed on such width concrete, even in instances on sandy soil.

The original concrete pavement design, in short, now has little or no factor of safety and under unfavorable conditions has not withstood the internal stresses produced by traffic flexure and variations in temperature and subsoil moisture. It is doubtful if such a safety factor can be introduced without considerably increasing the mass of concrete. It appears that under adverse soil condition there is considerable flexure with traffic.

To introduce sufficient steel to prevent flexure of a 4-inch or even 5-inch pavement over a shrunken or wet subgrade, or even a loose, sandy subgrade, is probably a doubtful economy. The existing longitudinal cracks that are accompanied by any separation or by "faulting" along the crack, or by displacement, are evidences of subgrade displacement or settlement or uneven subgrade shrinkage as a primary cause. Such defects are typical either with a single center crack or two longitudinal quarter cracks (see Plates XIX, XX, and LI) and the soil moisture sections in Appendix D appear to confirm this behavior.

Some special treatment of adverse subgrade soils, particularly of class 1, will be necessary. Capillary action and high moisture retentiveness and pronounced shrinkage must be met. The amount of admixture or the thickness of protective layers of noncapillary and supporting soils is not yet known. A flat subgrade might help to a slight extent to counteract such defects by eliminating some transverse tension due to normal pressure. The crown of $2\frac{3}{4}$ inches (see Plate XLVIII) in the present 15-foot standard design may well be reduced to $1\frac{3}{4}$ inches and with a flat subgrade and an added $1\frac{3}{4}$ inches maximum thickness there is an added factor against center longitudinal cracks.

By January, 1917, the State Highway Commission had constructed a total of 835 miles mostly of 4-inch by 15-foot concrete pavement. They continued to build the same type, except that the mix was increased to 1:2:4. In the light of the increase in thickness and the addition of reinforcing steel rods in 1920, it must now be inferred that the commission was again in 1917 governed in policy by the necessity for increased mileage. They say, with reference to the second bond issue:

> The untoward condition accompanying the World War soon set at naught the expectation of completing the State highway system with the proceeds of the second bond issue; and the commission, for the second time confronting an impossible task, is again forced to secure the greatest value receivable with the funds at its command.

This bond issue was based upon an estimate furnished from 1914–15 figures.

It is to be noted that the standard plans do not provide for widening the pavement on curves, although some widening of the "lune" type has been done subsequent to construction. The cross sections are, in general, noticeably "shallow" or "tight" and require a minimum amount of excavation.[26] However, in the northern part of the State, particularly, the climate appears to demand more pronounced drainage than has resulted from the present design. The sections do not provide for very pronounced superelevation, which is now frequently and successfully made one-half to 1 inch to the foot in many States. It is believed that the width of the main roads should be increased from the present width of 21 to 24 feet to a width of from 24 to 30 feet (see Plate LIII) except in heavy cuts. The crowns, as has been noted above, could well be reduced to $1\frac{3}{4}$ inches even on a wider pavement.

[25] General Orders 421 and 427, May 1 and Sept. 15, 1920, respectively.

[26] See Plate L.

PLATE L.

DISINTEGRATION AT EDGE AND TRAVELED SHOULDERS. 4 KERN C.

CROW-FOOT CRACKING AND BREAKING. 4 KERN B.

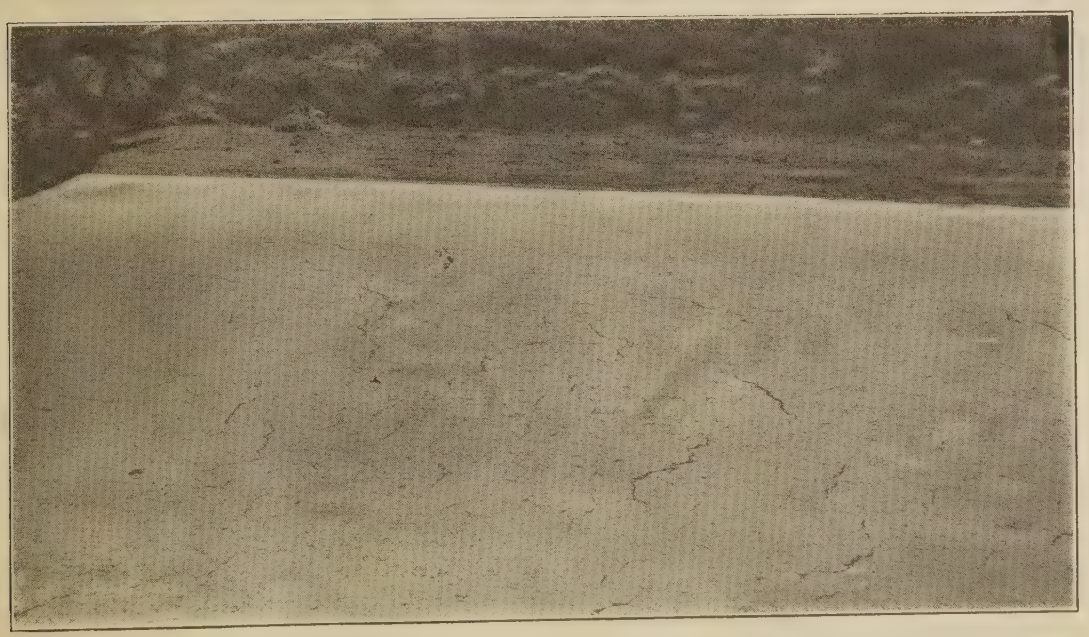
PLATE LI.

LONGITUDINAL CRACK WITH FAULTING. 7 SOLANO D.

LONGITUDINAL CRACK WITH FAULTING. 7 SOLANO D.

PLATE LII.

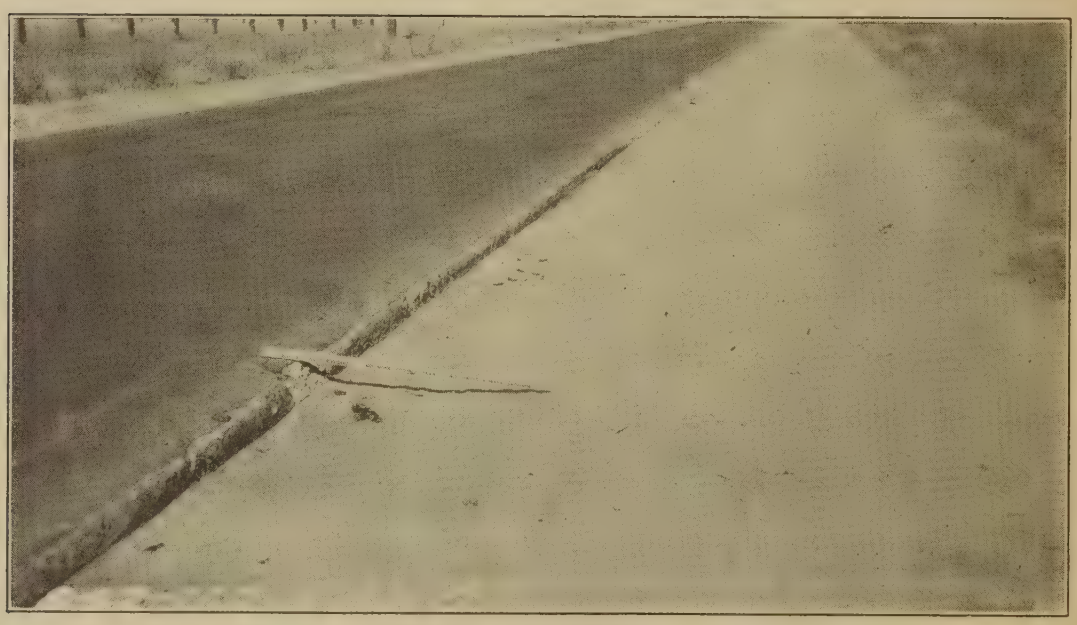
PITTING OF CONCRETE. 1 SONOMA C.



"CHECKING" OF CONCRETE. 4 KERN B.

PLATE LIII.

DEFECTIVE PLACEMENT OF MESH REINFORCING ON ADOBE. 2 SAN MATEO B.



SHOULDER WEAR FROM INSUFFICIENT WIDTH. 5 ALAMEDA A.

DESIGN OF GRADE ALIGNMENT AND SECTIONS.

Many miles of the California State highways lie on flat valley floors and have excellent alignment. There are scores of other miles of good location, including difficult mountain roads. It is disappointing in the valleys, therefore, to find location defects such as right-angle, section-corner turns and unnecessarily quick reverse curves in passing around railroad station sites and in the mountains and on steeper hills to encounter sharp blind curves and unnecessary rise and fall. Compensation of grade has not in all cases been sufficient to prevent exceeding the maximum grade if, in the future, the radii are lengthened.

It appears that the defects in grade and alignment are due largely to a too strict adherence to a standard. That standard is not invariably economical. A bolder line with considerably increased grading between Eckley and Martinez, for example, would probably not have added much to the first cost and will possibly ultimately have to be built, as this is the main route from San Francisco to Sacramento and is now rather dangerous.

Other locations on hill and mountain roads evidence minimum standards that are too low for trunk lines under present traffic conditions. There are numbers of curves of 50 and 60 foot radii and grades of 7 per cent that might have been eliminated or reduced at slight additional cost. In a few cases a radical change in line, though doubtless involving added right-of-way costs, would have been a great improvement.

It appears that valuable land has often been avoided and that a location that follows the topography closely has been the rule. These elements have at intervals impaired the alignment and grade.

Although the first report of the commission states that travel can proceed at 30 miles per hour over the State highway pavement, it is not safe to travel at that speed at many points, partly because of the narrow pavement and lack of superelevation, but largely because radii are too short. It would appear that where the method of cutting the inside bank to improve sight has been adopted, longer radii should have been selected in the first design. In the effort to economize in construction, it appears that at times (for example, on route 2, between King City and Santa Barbara) too many sharp, vertical curves have been used in order to fit the ground.

SPECIFICATIONS.

The State Highway Commission has until recently adhered to the 1912 specifications with few changes. These specifications appear to have been rigidly enforced. The grading has been neatly finished and the subgrade evidently well prepared. The original lean concrete mix of 1:2½:5 for a pavement should have been abandoned sooner, and the permission of 6 per cent of the fine aggregate passing a standard No. 100 sieve allows a possible excessive clay content. The requirements for coarse aggregate, with respect to size, grading, quality, and cleanliness are, in the light of recent developments, somewhat inadequate. It is believed the specifications should also exclude the use of alkaline or salt water and permit larger aggregate than 2½ inches. The originally required rough finish has been abandoned, but the finish now obtained can be improved. This rough finish was evidently for a pavement base, but it shows through a three-eighths-inch top and, where not covered, has doubtlessly tended to increase impact. The old specification for mixing until texture and color were uniform were evidently unsatisfactory and have been abandoned in favor of a ten-turn or one-minute mix. The requirements for curing by ponding or wet earth are excellent, but some checking (see Plate LII) due either to lax enforcement of this provision for curing or a too wet mix has occurred. The omission of transverse joints appears to have been a justifiable innovation, particularly in a frostless country, but it is believed there should be exceptions to this practice. The present requirement for concrete mixture of 1:2:4 if laid dry, it is believed, should produce a good pavement for traffic preponderantly rubber tired, but it is remarked that several States use a richer mix. Reinforcement has not been required until 1920, but the present specifications for about 42 pounds of one-half and three-eighths inch steel rods in the center plane per 100 square feet, it is believed, is excellent. The triangular mesh reinforcement used on Federal-aid project No. 1 was a failure, due possibly to improper placement. (See Plate LIII.)

With reference to Topeka specifications it is believed that an asphaltic oil of penetration not exceeding 70 should be specified, especially where the temperature exceeds 100° F., and where traffic is also unusually heavy.

With reference to oil macadam, eastern experience indicates that a surface treatment with the largest quantity of oil specified (1¾ gallons) will work into ridges and lumps under traffic. It may be inferred also that with oil paid for by the barrel there will be a corresponding tendency to use the maximum amount. Numerous cases of "viscosity waves" are observable throughout the State, although there are many miles of excellent oil macadam roads.

It is to be remarked that in general the specifications for concrete have, as shown by the tested samples, produced good quality, and that they have permitted an economic use of local material with a minimum of failures.

FURTHER DISCUSSION OF POLICY OF EXTENSION OF MILEAGE.

It is necessary in a critical analysis of the standard design to which the State Highway Commission has adhered for eight years to make full allowance for the advantage in extension of service made possible by its use. That this concrete construction was begun as a base, however, must not be overemphasized since it was continued for 694 additional miles, notwithstanding that supplementary surfacing for financial or other reasons was omitted. The design must be judged as above indicated with reference to the necessity to extend service and with respect to its continuance under the second bond issue, and, in addition, with reference to its upkeep and its adaptability to supplementary construction in those cases where it fails, owing to increase in volume or intensity of traffic or other causes.

It is to be remarked that the total motor-vehicle registration in 1920 is about six times that of 1912—and the total truck registration is approximately six times the 1915 figure. The State Highway Commission has as yet taken no State-wide traffic census.

That the thin, narrow pavement and close grading enabled the rapid extension of very serviceable miles of road is without question, and that the implied order in the legislative act of 1909 demanded extension is equally evident. Because the second bond issue was voted in 1915 and the third in 1919 may, in a sense, indicate such a capacity for road financing by the State as to deny the assumption that the State of California, at any time, was obliged to take chances with thin pavement in order to produce mileage, but it is undeniable that the very extension of the pavement developed sufficient sentiment to provide additional money in 1915 and again in 1919. So it can not be said in 1920 in the light of the fact that the great usefulness of the highway system is now proved, that the State would have realized its usefulness and provided funds in equal volume had not the system been extended as rapidly as it was and at some sacrifice of either temporary or ultimate durability to increased mileage.

There appears, however, to be a serious question in the light of the fact that 70 per cent of the defective pavement of classes D, E, and F occur on clay and adobe soils, as to the wisdom of a policy which continued the risk of a thin slab on such soils. It is undeniable, however, that a large mileage of the same thin pavement and on adverse soil still remains of classes A, B, and C. We find, however, no conclusive final demonstration of the best construction on the adverse soils, and, in that respect, failure to vary the design on such soils in the past has postponed the solution of this problem.

The concrete itself is shown by the tests of the sample cores and other samples to be uniformly good, its weight per cubic foot and absorption are practically constant, and the amount of coarse aggregate also. The crushing strength averages well above 3,000 pounds to the square inch. There is raised by the diagram of crushing strength by years (see Plate XXXIV) a question as to whether or not the concrete may be slowly deteriorating, but this condition has not been conclusively proved. More study of this phenomenon is required before any conclusion can be reached. Certainly the slight indicated decrease in strength would not account for any of the adverse conditions found in the pavement.

The question of initial extension vs. durability of design is further discussed under the topic of economics with reference to the indicated operating income. There seems grave question, however, as to the decision in 1917 to continue with the construction of pavement of a low factor of safety. By that time it would seem from a study of the summary tables of class condition that the behavior of the design on adverse soils should have been known. Still the change to a mix of 1:2:4 appears to be reflected in the class condition, since only 48 miles of the construction, beginning with 1917, has gone into classes D to F, inclusive, while 109 miles of construction prior to that time are in these classes.

The adaptability of the pavement laid to supplementary construction when it fails is indicated by about 37 miles of this work already done with 30-inch concrete shoulders and 1½-inch Topeka or other bituminous concrete surfacing and with second-story concrete. None of this work is sufficiently old to prove its ultimate durability. At present it appears to be carrying traffic with success. The expense of extensive repairing of certain sections prior to such reconstruction has been necessarily heavy. Much of the work so far done has been on roads in such sections that the cross section has not been a serious item, but in many places the roadbed will have to be widened before such supplementary construction of shoulders and surface top can be done.

PRESENT CONDITIONS.

With reference to the classification adopted for determining the present condition of concrete pavement, it is to be noted that for 4-inch concrete pavement class A is a rather abnormally high type. Pavement of class B, in the light of the present stage of development of concrete roads, appears to be a very normal type of concrete pavement—that is to say, transverse cracks at intervals of approximately 25 feet in a 4-inch pavement, without joints, may be considered characteristic. Pavement of class C, where no separation or faulting follows or accompanies the longitudinal cracks in a 4-inch slab, is not unexpected. But where faulting occurs along the longitudinal cracks or where there is

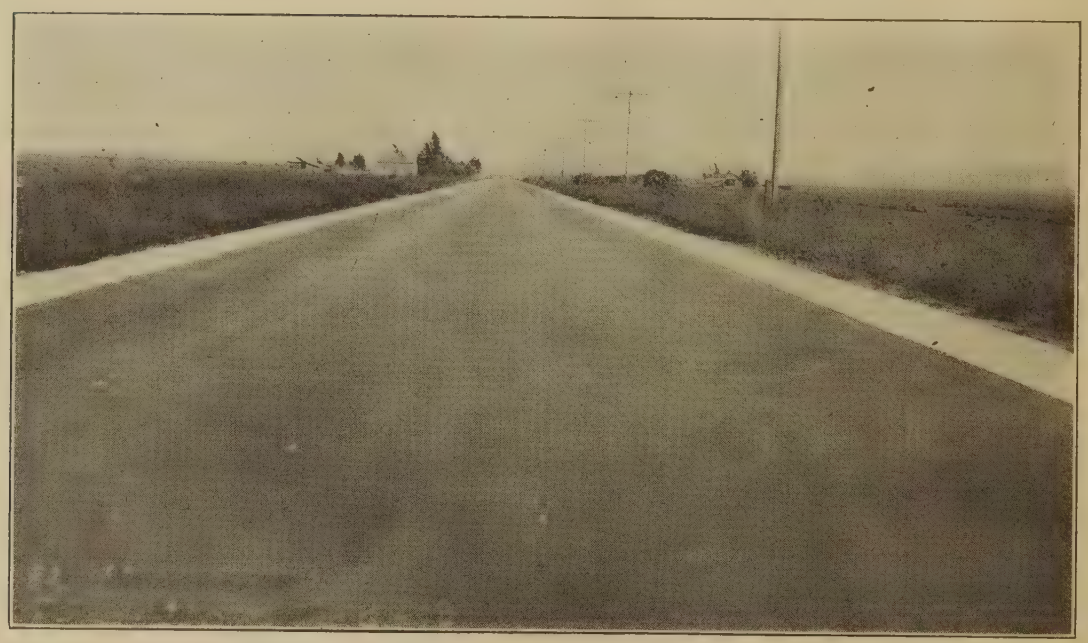
PLATE LIV.

OIL MACADAM PAVEMENT, LOS ANGELES COUNTY.

OIL MACADAM PAVEMENT, SACRAMENTO COUNTY.

PLATE LV.

SUPPLEMENTARY CONSTRUCTION SHOWING NEW 30-INCH SHOULDERS BEFORE LAYING OF TOPEKA SURFACING. 4 TULARE D.



FEDERAL-AID PROJECT NO. 24. SUPPLEMENTARY CONSTRUCTION WITH 30-INCH CONCRETE SHOULDERS AND TOPEKA SURFACING. 2 ORANGE B.

PLATE LVI.

SUPPLEMENTARY CONSTRUCTION. NEW LAYER OF 4-INCH CONCRETE ON TOP OF OLD OILED CONCRETE. ROUTE 2, LOS ANGELES COUNTY.

HEAVY PATCH REPAIRING. 7 COLUSA C.

a distinct separation of the two edges of the crack, an unusual condition is present, and the pavement must be regarded as considerably impaired as a structure. Such cases are not infrequent. Pavement of this class C may, however, and usually does, carry traffic without inconvenience. "Crowfoot" cracks at the edge of the pavement in any considerable number are distinct defects; they are not normal, and, when followed by settlement or disintegration, impair the service of the road. Pavement of class D, so cracked transversely and longitudinally as to form many areas of concrete of about 50 square feet, is decidedly defective, and when accompanied by settlement the service of the road is slightly impaired. Pavement of class E is a failure, and pavement of class F usually indicates that the concrete itself was bad or that the design of the pavement was inadequate. Travel on this class is in some instances quite difficult.

The State laid 1,365 miles of concrete and 1,262 miles were classified. Of that classified, 157 miles, or 12.5 per cent, was found in classes D, E, and F, but the degree of impairment is somewhat greater than the percentage, since the defective pavement is distributed throughout the State. The pavement in class F was largely concentrated, and less than 6 miles remains unrestored. The pavement in classes E and D will require reconstruction or heavy repairs and supplementary construction in the immediate future; there are about 114 miles of these two classes.

CONSTRUCTION AND MAINTENANCE.

An analysis of construction done and the costs thereof shows a rapid building of the important trunk highways to approximate completion and at a very reasonable cost. The total average percentage of construction costs on both day labor and contract work, chargeable to administration, engineering, and overhead, is 15.86 per cent, and is reasonable. The total overruns above the engineer's estimates, amounting to 6.24 per cent of the final total payment on construction, is low in view of the recent rise in prices. On day-labor jobs this corresponding percentage is higher, as expected, but is not excessive. The analysis in Appendix B of the 20 jobs, both contract and day labor, which presented the greatest apparent percentage of overruns, shows adequate reasons in practically every instance for such overruns of the estimate.

The accounts in the headquarters office on all work were found very complete and without discrepancies, and the cost figures here presented are accurate and official.

The direct charges for maintenance and improvement are found not to be excessive; the overhead and indirect charges, however, are apparently 19.2 per cent, overhead alone 12.5 per cent, which seems rather excessive. The direct control of maintenance of State highways by the State and the application of the net automobile revenues to this work is believed to be an excellent arrangement. The organization of maintenance under a headquarters maintenance engineer operating through the seven division offices appears adequate, though in some instances rather important job work appears to require more competent direct supervision.

There are at present under maintenance a total of 3,293 miles of State-controlled roads. These include 1,524 miles of earth and gravel roads, including special State roads built prior to 1912, and about 150 miles of oiled county pavement which the State has acquired from the counties. The expenditure for maintenance and improvement of earth and gravel roads is nearly one-third of the entire expenditure.

Since the law now allows the automobile money accruing to the State highway commission to be used for "improvement," it is found that considerable gravel and other surfacing has been done from this fund. The complete analysis or tabulation of distributed maintenance and improvement costs for each original project built by types and by years was not attempted, but the data for such analysis, while sometimes confusing, exists in the headquarters records. Sufficient investigation of the maintenance books was made to determine accurately the unit costs and the summary costs here given.

It appears that up to 1920 the commission has thought of necessary travel more in direct relation to the increasing maintenance costs rather than in respect to its influence on design of new construction. In this connection it is to be observed that in 1912 the increase of traffic could not be foreseen, but it would appear that by the end of 1915, when 1912 registrations had nearly doubled, that the 1918 registrations should have been foreseen.

ADMINISTRATIVE AND ENGINEERING ORGANIZATION.

The organization was highly developed. It has continued with little change since 1911. During the war, in common with other State highway departments, it was impaired by loss of personnel and its work was hampered by bad industrial conditions. It is not unwieldly and in form is unusually well adapted for the large-scale operation it has conducted. The salary scale is good.

The details of the engineering standards are carefully thought out and unusually complete. The standard plans and drawings are excellent, and the clear-cut precision of all engineering operation makes for speed and efficiency. The cost of all overhead and admin-

istrative and engineering items on contract jobs has averaged, as mentioned, 15.86 per cent, which, in view of the average low cost of construction per mile is very reasonable, as is similarly 15.88 per cent on day-labor jobs.

There is some evidence of a cramped condition in the functioning of the organization. It appears that headquarters control is so complete that it may inhibit those reciprocal actions necessary for healthy growth. There is a good opportunity with such an organization to develop this reaction function and initiative of the engineering employees who are in first-hand contact with the job. With the extraordinarily efficient directive functioning in all details, a corresponding return functioning of the organization through the division engineers to headquarters is desirable to develop new ideas with the extension of contact with the job. More initiative and authority would increase efficiency; thus the significance of the adobe reaction might have developed sooner and better alignment could have been produced by changes authorized during construction from reports by resident engineers.

The procedure in advertising and letting of contracts appears to be satisfactory. Some of the early contractors were inexperienced in road work and lost money. This condition has frequently occurred in other States. There is some apparent delay in the completion of final payments due to the routing of the paper.

CONVICT LABOR.

The State highway department officials report favorably regarding convict work. They bring out these points:-

The inaccessible, difficult, inspiring, and remote regions selected proved of advantage as environment and eliminated any criticism of competition with free labor or contact with undesirable "free" citizens.

The kind of work selected—heavy grading and clearing and grubbing—has been well adapted for success.

Unguarded, honor, and long-term convicts work best.

Good camps and food pay, and the outdoor life is wholesome.

There was difficulty at the start due to dual administrative control by the State prison authority and the State Highway Commission authority. This conflict was eliminated, and, with reward for good behavior and punishment for misbehavior, the work of the convicts has proved economical, especially during the war.

ECONOMIC AND OTHER STUDIES.

The one-day traffic at 103 stations on the State highways is an index of the use of the roads. This traffic day was distributed between August 7 and October 14 and throughout the State and the assumed daily average total of 2,500,000 vehicle miles should be representative for the summer interval, or, say, from June 1 to November 1. The resulting total vehicle miles of 375,000,000 is 70 per cent on the State-paved highways alone. These results 262,500,000 vehicle miles indicated service by such paved highway. The operating income at 5 cents a vehicle mile is $13,125,000.

To this amount must be added an operating income for the service interval November 1 to June 1. This latter amount can not be based on a traffic figure, but a minimum figure would indicate a total annual operating income of $20,000,000 for 1920.

For preceding years, when there were fewer miles of State pavement and fewer vehicles, the operating revenue can not be placed at a figure greater than the corresponding percentage of this total. Thus, in 1919, with an average of, say 450,000 motor vehicles in use, or 90 per cent of the 1920 average, and 93 per cent as much paved highway, there could not have been more than 83 per cent as much corresponding operating income. If the figure is placed at $15,000,000 there results an indicated gross operating revenue in the last two years of $35,000,000.

The element of assumption in the above reasoning is regarded as conservative. It is unnecessary to extend the computation to make immediately evident that the operating income from the State-paved highway system alone since 1913 has more than equaled the total expenditure for construction and for repair, improvement and maintenance of the entire mileage paved and graded by the State. The operating income from the graded portion and the portion built by the counties and acquired and maintained by the State has been disregarded. A corresponding decrease in operating revenue to the community would have occurred had the mileage been shortened by constructing a more durable type.

It is observed that during the decade 1910 to 1920 the estimated value of agricultural products has increased over 300 per cent; the population of the entire State, 44 per cent; and the population on the highways, exclusive of the two largest cities, 63 per cent.

These facts are evidence that the policy of extension of mileage of serviceable pavement was justified in the initial period. Highways, like the railroads, build up business, and a period of supplementary construction follows without financial strain because of increased operating revenue. The advertising value of the highway system has, without question, added to the population and to the tourist attraction.

Although for the most part the service rendered by the roads built is still uniformly good, it is very evident that the State can now well afford to raise the standard of construction. This standard must satisfy all motor-vehicle operators. The increase in the use of the trucks will doubtless for a time be increasingly rapid. It has been over 500 per cent in seven years

and 250 per cent during the past three years, and will demand a greatly increased factor of safety in the pavement.

But the increase in motor registration figures can not be the only index of the future duty of the roads. Additional information useful for the State Highway Commission can be secured by elaborating the form used for registration, but the necessity of a comprehensive traffic census at frequent intervals is great. Only a traffic count will determine the distribution of highway operations and yield corresponding control, both of design and maintenance allotments.

The maintenance and repair operation in the past period has involved excessive patching in certain sections due to the thin 4-inch pavement and the increase in traffic volume, weight, and speed. In the future, however, the demand for better quality of pavement service will become more exacting, and the increased traffic will require maintenance for various items on any type or standard of pavement, so that as the system develops the aggregate maintenance charge may be expected to increase.

There is evidence that relatively few vehicles have excessive total loads, but field weighings showed a large percentage of overload of trucks per inch width of solid tire. Unfortunately the exact record of this item was lost. It must be inferred that the infrequent and incidental heavy load is very destructive. Defects of the crowfoot type in the pavement are regarded as due solely to traffic impact on the thin slab with adverse subgrade condition. Crowfoot defects developed largely since September, 1920, on Federal-aid project No. 11, 10 Fresno D, between Coalinga and Oil King School, show by actual count 54 on the incoming or unloaded edge, against 283 on the outgoing or loaded edge. This is 6-inch pavement 18 feet wide on adobe. Not only heavy soils but also sandy soils underlie defects of this type, nor is a 4-inch pavement of greater width exempt from such defects. Excessive transverse cracks are also inevitable in a thin slab with any combination of adverse traffic and subgrade conditions.

Whatever design is adopted and whatever the legal speed and loading, there is evidence that better enforcement of the law is required.

CONCLUSION

The State highway system has in general been well selected and laid out. The mileage prescribed by law has far exceeded the funds and this discrepancy distorted the policy. The mileage remaining to be built is far in excess of the combined capacity of the third bond issue and all available Federal aid.

The deferred serial type of highway bond adopted is good, but the longest terms of every issue (44-45 years) are excessive, and the long terms will require millions of needless interest. The amounts of money were sufficient to permit planning of comprehensive construction programs and economy of large operations. The legal restrictions on the bonds were seriously embarrassing.[27]

The order of selection and construction of roads from year to year has been largely controlled by necessary policy.

The policy of permitting unpaved exceptions in small incorporated towns is uneconomical and impairs the efficiency of service of the State highways.

The financial administration has been scrupulously honest and careful, and the administrative and engineering costs have not been excessive, nor have final costs much exceeded the engineer's estimates.

Convict work has been successful, especially during the war, and from both aspects—the road work and reflex effect on the convict—it has been found necessary for success largely to eliminate any dual control of convicts on the job. The State prison funds clearly should bear some expense.

There has been a conspicuous growth of motor vehicle registration in California during the past construction period and a corresponding increase in volume and intensity of traffic. The commission evidently did not anticipate this increase and did not provide for it in their original design, nor did they count the traffic throughout the State. A very careful traffic census should be taken at intervals.

It is not believed that modern rubber-tired traffic on a smooth concrete road is abrasive, although solid-tired vehicles doubtless produce some breaking down of edges of separated cracks. No definite correlation was found between the total of vehicles and the condition of the concrete pavement itself, but the total traffic does largely determine the wear of shoulders and in many places does indicate a too-narrow width of pavement. It is believed that the impact of excessively heavily loaded trucks, particularly at high speeds, is very destructive to a thin, narrow pavement on adverse soils, but it is evident from the data that such trucks are in a small minority in California. Truck traffic is increasing; the size and number of commercial passenger busses is very noticeable and there may be expected a parallel increase in the development of commercial freight motor-truck traffic. Passenger busses are already operating on the 15-foot pavement to the disadvantage of other traffic, and the law allows a total width of farm load of 10 feet which is excessive for such pavement.

State authorities can not control the volume nor the distribution of traffic on the State highways, but complete and effective cooperation between the State highway commission and the motor vehicle department controlling the character of traffic is necessary. The creation of special State police exclusively to enforce the vehicle laws may be required.

There is a very large annual operating revenue to the community from the State highways. The total of this revenue has probably paid for all construction costs to date and would have been correspondingly decreased with less mileage.

A sum equal to the total net motor-vehicle fees at the present average rate will probably always be required for the absolute maintenance and improvement of State highways as construction of the 5,560 miles progresses. The original theory of a license to operate a motor vehicle is obsolete in a community where 97 per cent of traffic is by motor and the registration fee becomes a charge for use of the road. Systematic financing of the upkeep will ultimately adjust the average fee to the requirement of upkeep and also adjust the fee to the vehicle type to conform more closely to the impairment produced. An immediate increase of the State's share of the net automobile revenue would be good economy, as a large mileage of defective concrete road must be at once repaired and resurfaced.

The tables and the diagrams of condition and the statistics of sample core and soil tests clearly indicate:

(*a*) A correlation between defective pavements of classes D, E, and F, and adverse soil conditions; about 110 miles or 70 cent of 157 miles total of these three classes occur on soils of class 1, which includes all adobe soils.

(*b*) That since the average corrected testing strength of concrete cores is above 3,000 pounds to the square inch, the concrete itself is not generally defective in strength, nor does it show any wear by traffic.

(*c*) The class condition of all concrete pavement indicates a slow progressive deterioration and that type

[27] Such restrictions were removed by the vote of Nov. 2, 1920.

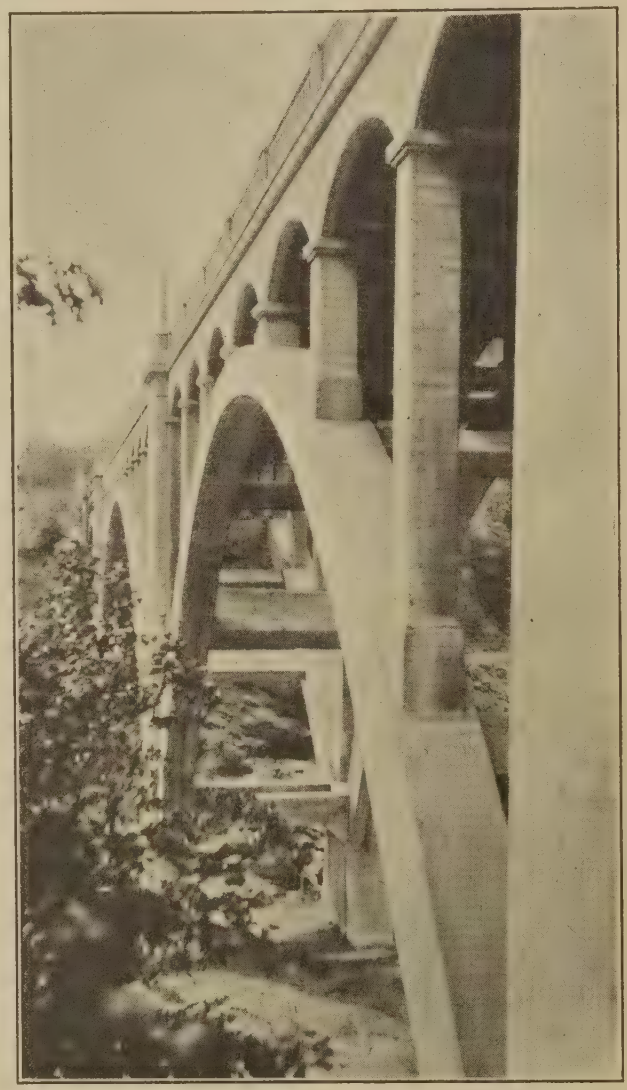
built tends to reach its approximate stage of classification comparatively soon and thereafter to change more slowly.

(*d*) The diagram showing average strength as determined by cores tested from concrete laid during the various years indicates that there may be a slow, progressive deterioration of the concrete itself, or "fatigue" in a thin slab subject to excessive flexure.

(*e*) There is no conclusive indication, so far, that the previous reinforcement in a 4-inch or 5-inch slab has produced a measurable increase in the quality or durability of the pavement.

(*f*) There is shown by the diagram of comparison between class condition of oil-surfaced concrete and the class condition of bare concrete a slight superiority in the average condition of the pavement surfaced with the three-eighths-inch oil top, but in view of obscured classification there is no demonstrated marked superiority of oil-surfaced pavement.

(*g*) Typical longitudinal (and other) cracking found on adverse subgrade soils, and shown by many of the 7,500 photographs now on file in the Bureau of Public Roads, indicates a distortion of the subgrade due to varying moisture content and shrinkage. The diagrams showing lines of equal moisture content clearly indicate the influence of the concrete pavement in preventing evaporation. The high capillarity of adobe soils and the great shrinkage in the long hot summers thus produce very unfavorable conditions for a thin pavement under increasing traffic.



DUNSMUIR BRIDGE OVER SACRAMENTO RIVER.

All unrepaired pavement of classes D to F, inclusive, which totals 120 miles and much of which is on adobe soils, is doubtless deteriorating and demands immediate repair and supplementary construction. It is doubtful if much of the pavement of these classes, especially on adobe, will ultimately prove an adequate base for a 1½-inch Topeka top. An adequate "second-story" concrete construction, if extended to a total width of 20 feet to thus include two new concrete shoulders of full depth, is to be preferred.

There are sufficient typical failures to show that in the future only designs of increased strength and adapted to resist such failure should be used. There will be necessary every possible precaution to prevent failure on adverse subsoils of adobe, clay adobe, or similar soils. On such soils, in the absence of any proved successful design, short sections only of tentative design should be attempted, or there should be first developed frank experimental construction to determine a workable and economical design.

Such a design will require the reinforcement now provided by the commission and a more massive type of concrete not less than 6 inches in average depth, and some adequate corrective treatment of subgrade, and possibly a form of "mulching" of shoulders to prevent evaporation. A flat subgrade is desirable and less crown.

It is believed that on the main roads more satisfactory results will follow a considerably bolder standard of location on hill and mountain grades, and that an increase in width of pavement to a minimum of 18 feet is now desirable, with more systematic widening and superelevation on curves.

Under modern traffic conditions there is an increasing demand for unimpaired alignment and fast travel between centers. To this end designs of highways must produce in general a road that can be traversed at a speed of 30 miles per hour throughout and without excessive operating costs due to changing speeds, etc. Therefore, first economy in grading becomes a rapidly decreasing advantage and must give way to the increased safety and comfort of travel.

There would be advantage in some exceptions to the present standard of no transverse joints. In the hot valleys considerable buckling of the 4-inch slab occurs, with attendant disintegration in infrequent instances. This tendency to buckle would doubtless be reduced by a thicker slab. Experiment with transverse joints at varying intervals is desirable on adverse or adobe soils. The future pavement will require a much larger factor of safety.

The policy of construction of grading and drainage structures and gravel surface only on certain roads in Districts 1, 2, and 3, in particular, was economically sound and deferring of paving up to the present doubtless justified. Through roads with a minimum of unimproved gaps resulted from such policy and with adequate standard for most interstate travel.

The standard of design and workmanship of structures is high and the costs have been very reasonable. Many bridges exhibit attractive designs of unusual elegance. In many places the side-hill type of inlets is not functioning. The prevailing type of guard rail is a reflection of the original purpose to protect horse-drawn traffic and might be modified to advantage in maintenance cost. Railroad grade crossing elimination, where undertaken, has been well done and will require constantly more attention and investment of State funds.

The standard of finish on concrete pavement has improved, but it is believed that still greater refinements will constantly be demanded and will probably pay in reduction of impact and resulting injury to and by traffic. It is not believed that the continued use of the three-eighths inch oil top is justified by past experience. The concrete should be laid not as a base but as a wearing surface.

There is nothing presented by the entire California study that indicates that concrete is not a successful pavement. One of the clearest results is the emphasis on the need of better subgrade protection. Highway grading is more exacting than railroad grading. There should be further studies in respect to:

(*a*) Traffic, with a new traffic census before June 1, 1921, and periodically thereafter.

(*b*) The indicated slow deterioration of the existing concrete, with continuing core tests.

(*c*) Soils, with considerable elaboration of the moisture-content study in pavement-protected subgrades, and the thickness of necessary protective soil layers on adobe, and of the required percentage of admixtures to lessen shrinkage and to increase the bearing power, also with respect to capillarity and critical moisture content.

(*d*) Alkali and its effect when present in the subgrade or in the mixing or ponding water.

It is believed that the motor vehicle registration law should provide separate records of the numbers of (*a*) all commercial trucks, including rubber-tired trucks; (*b*) all public freight trucks of certain important classes; (*c*) all foreign cars; and (*d*) all public passenger-carrying busses, and should contain strict provisions regarding tire conditions on all solid-tired trucks with respect to the minimum rubber cushions and flat tires, or projections, etc.

The work of the State Highway Commission and the highway engineer shows a continuous and intelligent devotion to public duty. Their construction operations have been widely extended under greatly varying conditions. A high degree of standardization was doubtless necessary and is evident. The failures (12.5 per cent of D, E, and F pavement) are not extensive, and some were inevitable on large-scale work. The 4-inch, 15-foot concrete pavement was continued beyond the point of success on adverse soils, and more time will be needed to develop a type of construction certain of success on such soils. The operations have produced a large mileage of very serviceable road and from an economic standpoint are conspicuously successful and of continuing benefit to the State. The operating income from the highways is now sufficiently large to insure the economic success of a considerably increased standard of construction.

75712—22——9

PLATE LVII.

ROUTE 9, LOS ANGELES COUNTY, SECTION A.

"COAST ROUTE." 2 SANTA BARBARA K.

PLATE LVIII.

ROUTE 7. SOLANO A.

ROUTE 9. LOS ANGELES A.

APPENDIX A.—DETAILS OF STATE HIGHWAY BONDS AND HIGHWAY SYSTEMS PROPOSED

FIRST BOND ISSUE, 1909—$18,000,000.

The nominal rate of interest is 4 per cent and the maximum terms 45 years. As the law provided that the bonds must not be sold below par the issue was hard to market and only $4,280,000 was sold publicly; the remainder, $13,720,000, was taken by the counties.[28] Had this procedure not been adopted the work could probably not have continued.

The State highway act of 1909 states relative to the first bond issue: "A system of State highways in and for the State of California shall be constructed and acquired as and in the manner provided by law by the department of engineering of said State, at a cost not to exceed eighteen million dollars. * * * The first four hundred of said bonds shall be due and payable on the third day of July, 1917, and four hundred of said bonds in consecutive numerical order shall be due and payable on the third day of July in each and every year thereafter until and including the third day of July, 1961. The interest accruing on all of said bonds that shall be sold shall be payable at the office of the treasurer of the State on the third day of January and the third day of July of each and every year after the sale of the same. * * * There is hereby created in and for the State treasury a fund to be known and designated as the 'State highway fund' and immediately after such sale of bonds the treasurer of the State shall pay into the State treasury and cause to be placed in such State highway fund the total amount received for said bonds, etc. The moneys placed in the State highway fund * * * shall be used exclusively for the acquisition of rights of way for and the acquisition and construction of said system of State highways."

SECOND BOND ISSUE, 1915—$15,000,000.

The nominal rate of interest on these bonds is 4½ per cent and the maximum term 40 years. These bonds found a ready market, except when the Federal Capital Issues Committee was in operation. The "State highway act of 1915" states relative to this second issue: "The fund created for the construction and acquisition of a system of State highways by the 'State highways act' of 1909, being inadequate to fully carry out the objects of said act, the uncompleted portions of said system prescribed by said 'State highways act' and certain extensions therefrom hereinafter specified shall be constructed, improved, and acquired as and in the manner provided by law by the department of engineering of said State at a cost not to exceed fifteen million dollars." The usual provisions follow for the sale of bonds and "The said bonds shall be payable * * * the first three hundred seventy-five of said bonds * * * on the third day of July, 1923, and three hundred seventy-five * * * on the third day of July in each and every year thereafter until and including the third day of July, 1962. The interest accruing * * * shall be payable on the third day of January and the third day of July of each and every year after the sale of the same." This act creates the "Second State highway fund" and directs that proceeds of the sale of the second bond issue be paid into it and used "exclusively for the acquisition of rights of way for and the acquisition, construction, and improvement of the uncompleted portions of the system of State highways prescribed by said 'State highway act.' And of said moneys so placed in said second State highway fund, the sum of three million dollars, or so much thereof as may be necessary, is hereby made available and shall be used exclusively for the acquisition of rights of way for and the acquisition, construction, and improvement of certain extensions," etc., extensions specified in the act.

THIRD BOND ISSUE, 1919, $40,000,000.

The nominal rate of interest provided in the law is 4½ per cent, and the maximum term 40 years, and the bonds are required to be sold at not less than par. The act for the third bond issue specified that the "interest shall be payable on the third day of January and the third day of July of each and every year after the sale of said bonds, and said bonds to become due and payable in annual parcels of one thousand bonds, commencing July 3, 1926, and ending July 3, 1965." The act established the "third State highway fund," into which the proceeds of sale of the third issue of bonds shall be paid and "the moneys in said 'third State highway fund' shall be used by the State department of engineering for the acquisition of rights of way and for the acquisition, construction, and improvement of uncompleted portions of the system of State highways prescribed by previous State highway acts and

[28] Act of Mar. 22, 1909, provided in section 8 that counties in which bond money was spent should pay the corresponding interest charges, and the act of Mar. 10, 1911, ch. 165, p. 339, provided amended and detailed procedure. Act of Apr. 23, 1913, authorizes counties to purchase State highway bonds.

certain additional highways named in the act providing for the third bond issue." Under the market conditions of 1919 and 1920, with these restrictions, the bonds were unsalable and the "board of control" arranged March 3, 1920, to sell $3,000,000 of the bonds for $92.59 plus and pay the discount, amounting to $222,160.50, with accrued Federal aid.[29]

This action was decided legal by the State appellate court, but the decision was appealed September 14 to the Supreme Court of the State of California. At the date of rendering this report the supreme court had not rendered a decision.[30]

For the purpose of authorizing the issue of bonds more readily saleable petition was made to cancel the unsold highway bonds of the third issue and authorize other bonds to the same amount to be issued at an interest rate not exceeding 6 per cent. This initiative measure was submitted to the people for vote at the general election November 2, 1920, and carried decisively. This measure also relieved the counties of the payment of interest on all State highway bonds in the future.

[29] The following is a memorandum from the State Highway Commission, dated September 25, 1920:

PROCEDURE REGARDING SALE OF $3,000,000 THIRD HIGHWAY BOND ISSUE.

The State board of control consists of three members appointed by the governor and holding office at his pleasure. This board examines and audits claims against State funds and has general powers of supervision over all matters concerning the financial business policies of the State.

The State board of control, together with the State treasurer, are authorized to designate as a "surplus fund" any money in the State treasury not necessary for immediate use.

The State board of control is further authorized to invest the same in the purchase of certain classes of bonds, including bonds of the State of California.

The only limitation on the authority of the State board of control is that no sale or exchange of bonds so purchased by the State board of control shall be made at a price which will result in a net loss to the State.

The advisory board of the State department of engineering is empowered by law to designate the fund or funds to which the State controller shall credit moneys received by the State treasurer from the United States Government under project agreements relating to Federal-aid work.

In the sale of State highway bonds the State treasurer must obtain therefor the par value of the bonds plus accrued interest.

In February, 1920, the State highway bonds were below par in the general market. The State treasurer had received certain moneys from the United States Government under project agreements relating to Federal-aid road work. Unless State highway bonds could be sold, State highway work would be vitally affected.

All State officials concerned therein concurred in the following plan of financing: Out of the surplus fund the board of control first paid to the State treasurer the par value of $3,000,000 worth of State highway bonds with accrued interest to the date of delivery and took the bonds into its own physical possession, custody, and control.

Thereafter the board of control sold and delivered such bonds to a syndicate of bond buyers at a price less than par. Upon the consummation of such sale and the receipt of moneys arising therefrom the board of control, by proper direction to the State controller and State treasurer, caused all such moneys to be paid into the surplus fund. Simultaneously therewith the advisory board of the State department of engineering directed the treasurer to cash certain Federal-aid road money checks and from the proceeds thereof to pay the sum of $222,160.50 into the surplus fund in such manner that the sum so paid into the surplus fund was exactly equivalent to the sum which would otherwise have been obtained from the sale of the bonds had the latter been sold in the open market for par and accrued interest to date of delivery.

The Appellate Court of the State of California has upheld the validity of the above plan and has decided that such transaction was not in violation of the provision of the surplus fund act to the effect that any sale or exchange of bonds purchased by the State board of control out of the surplus fund shall not be made at a price which will result in a net loss to the State.

The appellate court further held that the advisory board of the State department of engineering was within its powers in directing the crediting of Federal-aid road moneys to the surplus fund.

A petition for a rehearing of the matter is now pending in the State supreme court.

[30] A decision was rendered May 20, 1921, reversing the decision of the lower court.

Tables 32 to 36, inclusive, which follow, show the annual payments which will be required to pay interest and principal on the various bond issues until all are completely amortized.

TABLE 32.—*Schedule of interest and principal first bond issue—$18,000,000.*

Year.	Principal outstanding.	Interest for the year (4 per cent).	Principal repaid.	Total payments.
1911	$400,000			
1912	1,731,000	$16,000		$16,000
1913	5,225,000	114,800		114,800
1914	11,715,000	311,100		311,100
1915	16,400,000	514,300		514,300
1916	18,000,000	688,000		688,000
1917	17,600,000	720,000	$400,000	1,120,000
1918	17,200,000	704,000	400,000	1,104,000
1919	16,800,000	688,000	400,000	1,088,000
1920	16,400,000	672,000	400,000	1,072,000
1921	16,000,000	656,000	400,000	1,056,000
1922	15,600,000	640,000	400,000	1,040,000
1923	15,200,000	624,000	400,000	1,024,000
1924	14,800,000	608,000	400,000	1,008,000
1925	14,400,000	592,000	400,000	992,000
1926	14,000,000	576,000	400,000	976,000
1927	13,600,000	560,000	400,000	960,000
1928	13,200,000	544,000	400,000	944,000
1929	12,800,000	528,000	400,000	928,000
1930	12,400,000	512,000	400,000	912,000
1931	12,000,000	496,000	400,000	896,000
1932	11,600,000	480,000	400,000	880,000
1933	11,200,000	464,000	400,000	864,000
1934	10,800,000	448,000	400,000	848,000
1935	10,400,000	432,000	400,000	832,000
1936	10,000,000	416,000	400,000	816,000
1937	9,600,000	400,000	400,000	800,000
1938	9,200,000	384,000	400,000	784,000
1939	8,800,000	368,000	400,000	768,000
1940	8,400,000	352,000	400,000	752,000
1941	8,000,000	336,000	400,000	736,000
1942	7,600,000	320,000	400,000	720,000
1943	7,200,000	304,000	400,000	704,000
1944	6,800,000	288,000	400,000	688,000
1945	6,400,000	272,000	400,000	672,000
1946	6,000,000	256,000	400,000	656,000
1947	5,600,000	240,000	400,000	640,000
1948	5,200,000	224,000	400,000	624,000
1949	4,800,000	208,000	400,000	608,000
1950	4,400,000	192,000	400,000	592,000
1951	4,000,000	176,000	400,000	576,000
1952	3,600,000	160,000	400,000	560,000
1953	3,200,000	144,000	400,000	544,000
1954	2,800,000	128,000	400,000	528,000
1955	2,400,000	112,000	400,000	512,000
1956	2,000,000	96,000	400,000	496,000
1957	1,600,000	80,000	400,000	480,000
1958	1,200,000	64,000	400,000	464,000
1959	800,000	48,000	400,000	448,000
1960	400,000	32,000	400,000	432,000
1961		16,000	400,000	416,000
Total		18,204,200	18,000,000	36,204,200

TABLE 33.—*Schedule of interest and principal second bond issue—$15,000,000.*

Year.	Principal outstanding.	Interest for the year (4½ per cent).	Principal repaid.	Total payments.
1917	$5,000,000			
1918	7,116,000	$225,247		$225,247
1919	12,500,000	385,110		385,110
1920	13,000,000	573,750		573,750
1921	15,000,000	585,000		585,000
1922	15,000,000	675,000		675,000
1923	14,625,000	675,000	$375,000	1,050,000
1924	14,250,000	658,125	375,000	1,033,125
1925	13,875,000	641,250	375,000	1,016,250
1926	13,500,000	624,375	375,000	999,375
1927	13,125,000	607,500	375,000	982,500
1928	12,750,000	590,625	375,000	965,625
1929	12,375,000	573,750	375,000	948,750
1930	12,000,000	556,875	375,000	931,875
1931	11,625,000	540,000	375,000	915,000
1932	11,250,000	523,125	375,000	898,125
1933	10,875,000	506,250	375,000	881,250
1934	10,500,000	489,375	375,000	864,375
1935	10,125,000	472,500	375,000	847,500
1936	9,750,000	455,625	375,000	830,625
1937	9,375,000	438,750	375,000	813,750
1938	9,000,000	421,875	375,000	796,875
1939	8,625,000	405,000	375,000	780,000
1940	8,250,000	388,125	375,000	763,125

TABLE 33.—*Schedule of interest and principal second bond issue—$15,000,000*—Continued.

Year.	Principal outstanding.	Interest for the year (4½ per cent).	Principal repaid.	Total payments.
1941	$7,875,000	$371,250	$375,000	$746,250
1942	7,500,000	354,375	375,000	729,375
1943	7,125,000	337,500	375,000	712,500
1944	6,750,000	320,625	375,000	695,625
1945	6,375,000	303,750	375,000	678,750
1946	6,000,000	286,875	375,000	661,875
1947	5,625,000	270,000	375,000	645,000
1948	5,250,000	253,125	375,000	628,125
1949	4,875,000	236,250	375,000	611,250
1950	4,500,000	219,375	375,000	594,375
1951	4,125,000	202,500	375,000	577,500
1952	3,750,000	185,625	375,000	560,625
1953	3,375,000	168,750	375,000	543,750
1954	3,000,000	151,875	375,000	526,875
1955	2,625,000	135,000	375,000	510,000
1956	2,250,000	118,125	375,000	493,125
1957	1,875,000	101,250	375,000	476,250
1958	1,500,000	84,375	375,000	459,375
1959	1,125,000	67,500	375,000	442,500
1960	750,000	50,625	375,000	425,625
1961	375,000	33,750	375,000	408,750
1962	.....	16,875	375,000	391,875
Total	.....	16,281,607	15,000,000	31,281,607

Actual amount sold is $13,000,000 only.

TABLE 34.—*Showing approximate total bond requirements, first and second issues.*

[All totals include both principal retired and interest from 1912 to 1962, inclusive, by years.]

Year.	Total first-issue payment.	Total second-issue payment.[1]	Total for both issue.
1912	$16,000	.....	$16,000
1913	114,800	.....	114,800
1914	311,100	.....	311,100
1915	514,300	.....	514,300
1916	688,000	.....	688,000
1917	1,120,000	.....	1,120,000
1918	1,104,000	$225,247	1,329,247
1919	1,088,000	385,110	1,473,110
1920	1,072,000	573,750	1,645,750
1921	1,056,000	585,000	1,641,000
1922	1,040,000	675,000	1,715,000
1923	1,024,000	1,050,000	2,074,000
1924	1,008,000	1,033,125	2,041,125
1925	992,000	1,016,250	2,008,250
1926	976,000	999,375	1,975,375
1927	960,000	982,500	1,942,500
1928	944,000	965,625	1,909,625
1929	928,000	948,750	1,876,750
1930	912,000	931,875	1,843,875
1931	896,000	915,000	1,811,000
1932	880,000	898,125	1,778,125
1933	864,000	881,250	1,745,250
1934	848,000	864,375	1,712,375
1935	832,000	847,500	1,679,500
1936	816,000	830,625	1,646,625
1937	800,000	813,750	1,613,750
1938	784,000	796,875	1,580,875
1939	768,000	780,000	1,548,000
1940	752,000	763,125	1,515,125
1941	736,000	746,250	1,482,250
1942	720,000	729,375	1,449,375
1943	704,000	712,500	1,416,500
1944	688,000	695,625	1,383,625
1945	672,000	678,750	1,350,750
1946	656,000	661,875	1,317,875
1947	640,000	645,000	1,285,000
1948	624,000	628,125	1,252,125
1949	608,000	611,250	1,219,250
1950	592,000	594,375	1,186,375
1951	576,000	577,500	1,153,500
1952	560,000	560,625	1,120,625
1953	544,000	543,750	1,087,750
1954	528,000	526,875	1,054,875
1955	512,000	510,000	1,022,000
1956	496,000	493,125	989,125
1957	480,000	476,250	956,250
1958	464,000	459,375	923,375
1959	448,000	442,500	890,500
1960	432,000	425,625	857,625
1961	416,000	408,750	824,750
1962	.....	391,875	391,875
Total	36,204,200	31,281,607	67,485,807

[1] Assumed completely sold.

TABLE 35.—*Schedule of interest and principal, third bond issue—$40,000,000.*

[Interest assumed 6 per cent.]

Year.	Principal outstanding.	Interest for the year.	Principal repaid.	Total payments.
1920	[1] $3,000,000	.....	.....	.....
1921	[2] 6,000,000	[1] $135,000	.....	$135,000
1922	[2] 12,000,000	315,000	.....	315,000
1923	[2] 21,000,000	675,000	.....	675,000
1924	[2] 30,000,000	1,215,000	.....	1,215,000
1925	40,000,000	1,755,000	.....	1,755,000
1926	39,000,000	2,355,000	$1,000,000	3,355,000
1927	38,000,000	2,310,000	1,000,000	3,310,000
1928	37,000,000	2,265,000	1,000,000	3,265,000
1929	36,000,000	2,220,000	1,000,000	3,220,000
1930	35,000,000	2,160,000	1,000,000	3,160,000
1931	34,000,000	2,100,000	1,000,000	3,100,000
1932	33,000,000	2,040,000	1,000,000	3,040,000
1933	32,000,000	1,980,000	1,000,000	2,980,000
1934	31,000,000	1,920,000	1,000,000	2,920,000
1935	30,000,000	1,860,000	1,000,000	2,860,000
1936	29,000,000	1,800,000	1,000,000	2,800,000
1937	28,000,000	1,740,000	1,000,000	2,740,000
1938	27,000,000	1,680,000	1,000,000	2,680,000
1939	26,000,000	1,620,000	1,000,000	2,620,000
1940	25,000,000	1,560,000	1,000,000	2,560,000
1941	24,000,000	1,500,000	1,000,000	2,500,000
1942	23,000,000	1,440,000	1,000,000	2,440,000
1943	22,000,000	1,380,000	1,000,000	2,380,000
1944	21,000,000	1,320,000	1,000,000	2,320,000
1945	20,000,000	1,260,000	1,000,000	2,260,000
1946	19,000,000	1,200,000	1,000,000	2,200,000
1947	18,000,000	1,140,000	1,000,000	2,140,000
1948	17,000,000	1,080,000	1,000,000	2,080,000
1949	16,000,000	1,020,000	1,000,000	2,020,000
1950	15,000,000	960,000	1,000,000	1,960,000
1951	14,000,000	900,000	1,000,000	1,900,000
1952	13,000,000	840,000	1,000,000	1,840,000
1953	12,000,000	780,000	1,000,000	1,780,000
1954	11,000,000	720,000	1,000,000	1,720,000
1955	10,000,000	660,000	1,000,000	1,660,000
1956	9,000,000	600,000	1,000,000	1,600,000
1957	8,000,000	540,000	1,000,000	1,540,000
1958	7,000,000	480,000	1,000,000	1,480,000
1959	6,000,000	420,000	1,000,000	1,420,000
1960	5,000,000	360,000	1,000,000	1,360,000
1961	4,000,000	300,000	1,000,000	1,300,000
1962	3,000,000	240,000	1,000,000	1,240,000
1963	2,000,000	180,000	1,000,000	1,180,000
1964	1,000,000	120,000	1,000,000	1,120,000
1965	.....	60,000	1,000,000	1,060,000
Total	.....	53,205,000	40,000,000	93,205,000

[1] $3,000,000 sold Mar. 2, 1920, at discount of $221,160.50, at 4½ per cent nominal rate.
[2] Amounts sold are assumed.

TABLE 36.—*Showing approximate total highway bond requirements, first, second, and third issues.*[1]

[All totals include both principal retired and interest from 1912 to 1965, inclusive, by years.]

Year.	Total for three issues.	Year.	Total for three issues.
1912	$16,000	1940	$4,075,125
1913	114,800	1941	3,982,250
1914	311,100	1942	3,889,375
1915	514,300	1943	3,796,500
1916	688,000	1944	3,703,625
1917	1,120,000	1945	3,610,750
1918	1,329,247	1946	3,517,875
1919	1,473,110	1947	3,425,000
1920	1,645,750	1948	3,332,125
1921	1,776,000	1949	3,239,250
1922	2,030,000	1950	3,146,375
1923	2,749,000	1951	3,053,500
1924	3,256,125	1952	2,960,625
1925	3,763,250	1953	2,867,750
1926	5,330,375	1954	2,774,875
1927	5,252,500	1955	2,682,000
1928	5,174,625	1956	2,589,125
1929	5,096,750	1957	2,496,250
1930	5,003,875	1958	2,403,375
1931	4,911,000	1959	2,310,500
1932	4,818,125	1960	2,217,625
1933	4,725,250	1961	2,124,750
1934	4,632,375	1962	1,631,875
1935	4,539,500	1963	1,180,000
1936	4,446,625	1964	1,120,000
1937	4,353,750	1965	1,060,000
1938	4,260,875		
1939	4,168,000	Total	160,690,807

[1] Table assumes last installment, $2,000,000, of second issue sold, and interest rate of 6 per cent for third issue, and assumes also the sales indicated in detailed table showing interest and principal of third bond issue.

The list of highways laid out by the commission in compliance with the highway act of 1909 and the adjoined list of highways described in the laws of 1915 and 1919 to be built under the respective bond issues of those years are given below:

FIRST BOND ISSUE.

Route.	From—	To—	Mileage.
1	San Francisco	Crescent City	371.2
2	do	San Diego	481.8
3	Sacramento	Oregon line	291.3
4	do	Los Angeles	359.0
5	Stockton	Santa Cruz via Oakland	116.9
6	Sacramento	Woodland Junction	14.3
7	Tehama Junction	Benicia	142.7
8	Ignacio	Cordelia, via Napa	38.6
9	San Fernando	San Bernardino	53.5
10	Goshen	Hanford	13.2
11	Sacramento	Placerville	46.5
12	San Diego	El Centro	127.5
13	Salida	Sonora	49.2
14	Albany	Martinez	20.6
15	Williams	Colusa	8.7
16	Hopland	Lakeport	19.3
17	Roseville	Nevada City	33.4
18	Merced	Mariposa	39.2
19	Route 9, west of Claremont	Riverside	17.7
20	Redding	Weaverville	50.0
21	Route 3, near Richvale	Oroville	7.0
22	San Juan Bautista	Hollister	7.1
23	Saugus	Bridgeport	337.5
24	Route 4, near Lodi	San Andreas	36.6
25	Nevada City	Downieville	47.0
28	Redding	Alturas	151.1
29	Red Bluff	Susanville	100.0
30	Oroville	Quincy	[1] 67.0
34	Route 4, near Arno	Jackson	34.4
	Total		3,082.3

SECOND BOND ISSUE.

10	Hanford	San Lucas	98.25
18	Mariposa	El Portal	32.60
20	Douglas City	Route 1, Arcata	102.00
26–27	San Bernardino	Yuma, via El Centro	195.86
31	do	Barstow	76.33
32	Route 4, near Califa	Gilroy	83.45
33	Route 4, near Bakersfield	Paso Robles	91.22
	Total		679.71

THIRD BOND ISSUE.

58	Mojave	Needles, via Barstow	255
60	Oxnard	San Juan Capistrano	86
57	Santa Maria	Freemans, via Bakersfield	202
55	San Francisco	Santa Cruz	67
53	Rio Vista	Fairfield	24
[2] 37	Auburn	Verdi	95
15	Ukiah	Emigrant Gap	212
[3] 38	Truckee	Tahoe City	
1	Crescent City	Oregon line	40
51	Santa Rosa	Shellville	24
63	Big Pine	Oasis	40
[4] 11	Placerville	Sportsman's Hall	10
21	Oroville	Quincy	27
[5] 41	General Grant National Park	Kings River Canyon	20
49	Calistoga	Lower Lake	32
64	Mecca	Blythe	100
50	Runsey	Lower Lake	35
62	Azusa	Pine Flats in San Gabriel Canyon.	10
61	La Canada	Mount Wilson Road, via Arroyo Seco.	10
59	Lancaster	Baileys	40
48	McDonalds	Mouth of Navarro River	47
56	Carmel	San Simeon	97
46	Klamath River bridge, route 3.	Route 1, near mouth of Klamath River.	177
29	Susanville	Nevada State line	53
22	Pacheco Pass Road into Hollister.		8
10	Visalia	Sequoia National Park	36
43	Deep Creek	Metcalf Creek	14
47	Orland	Chico	20
52	Tiburon	Alto	5
54	Near Michigan Bar	Drytown	12
	Total		1,798

[1] Route 30 has been abandoned, and route 21 extended to cover approximately the same mileage.
[2] Ninety-five miles maintained under special appropriation roads.
[3] Fifteen miles maintained under special appropriation roads.
[4] Ten miles maintained under special appropriation roads.
[5] Fourteen miles maintained under special appropriation roads.

Tabulation of State special appropriation roads taken over from department of engineering.

Division I:
None in this division.

Division II:

	Miles.
Lassen County, route 28, Lassen State highway	29.0
Sierra County (*a*), route 36, Sierra State highway	2.9
Trinity County, route 35, Trinity-Humboldt State road	33.0
Total for Division II	64.9

Division III:

Alpine County—		
Route 34, Carson Pass branch	14.1	
Route 23, trunk line, El Dorado County line to Picketts	2.3	
Route 23, Picketts to Woodfords	6.3	
Route 23, Woodfords to Loop	12.5	
Route 24, Calaveras branch, junction of Alpine trunk to Calaveras County	31.8	
Route 13, Sonora-Mono Road, Sonora Pass to Brightmans Flat	12.5	
Total		79.5
Amador County, route 34, Alpine Road, Carson Pass Basin		57.8
Butte County, route 45, Westerly County, line to Biggs		9.3
Calaveras County, route 24, Big Trees to Alpine County line		22.6
Eldorado County—		
Route 11, Placerville to State line	65.0	
Route 38, Myers-McKinneys	24.0	
Route 23, Osgoods to Alpine County line	10.7	
Total		99.7
Glenn County, route 45, Willows to east county line		22.4
Mariposa County, route 40, Tioga Road		2.2
Nevada County—		
Route 37, Emigrant Gap	21.1	
Route 38, McKinneys-Donner Lake	5.6	
Total		26.7
Placer County—		
Route 37, Auburn-Emigrant Gap	43.85	
Route 37, Emigrant Gap	14.7	
Route 38, McKinneys-Donner Lake	21.8	
Route 38, Myers-McKinneys	1.25	
Route 39, Tahoe City-Crystal Bay	11.2	
Total		92.8
Sierra County, route 37, Nevada County line to State line		12.5
Tuolumne County—		
Route 13, Sonora-Mono	31.5	
Route 40, Tioga Road (exclusive of Yosemite Park)	50.8	
Total		82.3
Total for Division III		527.3

Division IV:

Santa Cruz County, route 42, California Redwood Park	16.0

Division V:
None in this division.

Tabulation of State special appropriation roads taken over from department of engineering—Continued.

Division VI:	Miles.	Miles.
Fresno County, route 41, Kings River Canyon (built)		14.5
Mono County—		
Routes 13 and 23, Sonora Pass to Bridgeport	34.0	
Route 40, Mono Lake Basin	12.3	
Route 40, Tioga Pass to Mono Lake Basin River	1.0	
Route 23, Alpine County line to Little Antelope Valley	9.4	
Route 23, Little Antelope Valley to junction, Sonora-Mono Road	17.0	
Total		73.7
Total for Division VI		88.2

Tabulation of State special appropriation roads taken over from department of engineering—Continued.

Division VII:	Miles.
San Bernardino County—	
Route 43, end of county pavement to most easterly point Great Bear Lake, say 60 miles	60.0

RECAPITULATION.

	Miles.
Division I	0.0
Division II	64.9
Division III	527.3
Division IV	16.0
Division V	0.0
Division VI	88.2
Division VII	60.0
Total	756.4

APPENDIX B

There follows a table showing a comparison of the engineers estimate and final cost on 20 selected jobs which showed the greatest overruns of final costs. Following the table is a discussion of these jobs.

Comparison of engineer's estimate and final cost of 20 selected jobs.

CONTRACT JOBS.

Contract No.	Division.	Route.	County.	Section.	Class of work.	Cost of labor and materials.		
						Engineer's preliminary.	Final paid.	Overrun (per cent).
2	1	1	Mendocino	A	Grading	$70,508	$93,019	32
215	1	1	do	F	do	95,266	128,878	36
235	2	3	Siskiyou	A	do	15,273	24,237	58
207	3	3	Butte	A	15-foot concrete base	77,534	107,469	38
227	3	21	do	A	do	100,933	143,778	34
16	4	1	Sonoma	B	do	129,482	198,079	52
102	4	5	Santa Clara	B	Grading	79,725	104,555	31
83	4	5	Santa Cruz	A	do	63,996	86,772	35
157	6	18	Mariposa	A	do	53,596	72,342	35
73	7	2	Ventura	F, G	15-foot concrete base	54,819	71,091	30
			Totals			741,132	1,029,120	39

DAY-LABOR JOBS.

D-74	2	3	Siskiyou	A	Grading	$3,500	$9,418	170
D-2	3	11	Eldorado	B	12-foot oil macadam	25,619	97,392	280
D-5	3	11	do	C	12-foot concrete base, oiled	61,291	160,375	160
D-61	5	2	Monterey	A	15-foot concrete base	21,352	51,192	140
D-108	6	18	Mariposa	B	Grading	51,195	141,806	160
D-129	6	23	Mono	C	Bridges	2,318	7,158	210
D-11	7	2	San Diego	B, C	Oil surfacing	11,086	32,240	190
	7	2	do	D	15-foot concrete base	1,137	7,679	570
	7	2	Ventura	A	Oil surface and shoulders	5,005	16,725	230
	7	12	San Diego	C	Grading	6,000	26,542	340
			Totals			187,503	549,527	193

Inquiry at the office of the State Highway Commission relative to the reasons for the overruns shown in the foregoing statement elicited the following:

CONTRACT JOBS.

No. 2: The contractor abandoned this job during the winter of 1912 and left it in a deplorable condition so that when the State took over the work considerable extra expense was incurred in getting it back into shape and bringing it to completion. A gravel surfacing was also applied to the job which was not contemplated in the preliminary estimate.

No. 215: Upon this contract there were several slides aggregating in the neighborhood of 6,000 cubic yards. The bid on this contract was $24,760.24 over the preliminary estimate.

No. 235: Several slides occurred on this job, which increased the cost considerably. The contractor's bid on this job was $5,843.55 over the estimate.

No. 207: This contract was completed by State forces upon the failure of the contractor. The excavation overran 7,425 cubic yards and the preliminary estimate appears to have been somewhat too low. The cost of material overran the estimate by $4,084.35.

No. 227: The original estimate was apparently too low for the work at the time bids were received. Excess yardage excavation, 7,516 cubic yards. Extra work, $10,715.33.

No. 16: Work on this contract done by the contractor was found to be very faulty and it was necessary for the State to replace considerable quantities of work. This contract was completed by State forces after the failure of the contractor, who left the work in a deplorable condition. There was also an increase in quantities of excavation and concrete put in on this job, which tended to make the cost excessive. [Note low bid and excess quantities of work done by contractor.]

No. 102: An increase of 49,900 cubic yards of excavation over that shown in the preliminary estimate accounts for the increase in cost of this job. This increase in yardage was due to slides, damage by storms, line changes, grade changes, etc., which developed during the progress of the work.

No. 83: An increase of 39,954 cubic yards of excavation over that shown in the preliminary estimate accounts for the bulk of the difference between the preliminary estimate and the final cost. This increase in excavation quantities was due to line and grade changes to save large redwoods and for other reasons which developed during the course of construction.

No. 157: Considerably more rock excavation was encountered than had been expected, although the total yardage (earth and rock) excavated was practically the same as originally estimated. [The original estimate for rock was $1 a cubic yard and the contract price was $1.50 a cubic yard. The estimate for earth excavation was 45 cents a cubic yard and the contract price was 38 cents.]

No. 73: The original contract covered 3.58 miles in Section F, with an optional extension of 1.47 miles, which, on account of right-of-way difficulties, was not included in the contractor's work. This 1.47 miles was, however, improved about the same time contract No. 73 was in progress, but by State forces and the charges carried under contract No. 73. This work amounted to $10,329.38 for labor and probably about an equal amount for materials, although there is no way of segregating the material charges on this stretch.

DAY-LABOR JOBS.

Except D-2 and D-5, all day-labor jobs (listed above) were not advertised for bids, and so no comparison can be made of bids. There are no final estimates of quantities on these day-labor jobs, so there is shown no comparison of quantities and unit costs.

D-74: The engineer's preliminary estimate for this work should be $23,325. The work originally contemplated, at an estimated cost of $3,500 and covering 0.3 mile, was extended to include 1.52 miles. With the coming of winter work was

shut down and the following spring was let under contract No. 235.

D–2: The work contemplated originally was water-bound macadam. The construction was oil macadam, which item alone increased the cost of this work about $6,000. A much greater amount of rock excavation was encountered than had been estimated. A great number of shallow rock cuts required drilling and blasting, the rock breaking into such large pieces that it was impracticable to use them in the light fills. The cost of rock excavation made the unit cost of excavation exceedingly high as compared with the estimated unit costs.

The overrun of 10,000 yards of excavation was due to excavating 6 inches below subgrade in rock and loose cuts to reach the grade desired and to the necessary waste of large bowlders. Figured at actual unit cost, the excess yardage increased the cost of this work about $14,000.

An excess of 2,600 tons of crushed rock and screenings over the preliminary estimate was necessary to complete the work, at an additional cost of approximately $6,000. The final cost also includes the purchase of considerable equipment, viz: Oil-heating plant, tank wagons, camp outfits, and other incidentals not included in the preliminary estimate.

D–5: The original estimate for this work contemplated a water-bound macadam. The construction was a 12-foot concrete base. In making the preliminary estimate for excavation due consideration was not given the character of the material to be excavated. The cost of drilling and shooting alone was about one-half of the original estimated amount for excavation.

The final cost of this work includes the purchase of considerable equipment, viz: Paving mixer, engine, pump, pipe line, paving equipment, camp outfits, dump wagon, etc.

D–61: The engineer's estimate is for placing concrete base on 2.1 miles (approximately). The commission voted later to extend this work from Saguinta to the easterly boundary, a distance of 4.34 miles.

D–108: Heavier rock excavation was encountered on this section than had been contemplated from preliminary examination of the route, which greatly increased the cost of the work. A concrete culvert was built at China Gulch.

D–129: The engineer's preliminary estimate was for timber bridges. Plans were later changed to make bridge floors of concrete. Also one-half mile of grading was done under this project.

D–11: The original estimate was for oiling the pavement only on these two sections. Additional work done, not included in the original estimate, consisted in oiling the shoulders. The shoulders were regraded and the weeds cut. On steep grades in cuts the shoulders were excavated to a depth of 4 inches, beach gravel and a binder of loam applied and rolled. On this the regular shoulder was built. Due to storm damage and failure of the water supply it was necessary to establish a new oil pit at Oceanside, the cost of same being charged to this project.

In addition to the above oiling work, the bridge over Loma Alta Creek was back filled; at two right-angle turns near Carl the concrete base was widened, and concrete walls at both abutments of the San Luis Rey Bridge were built.

D–80: The engineer's preliminary estimate was for placing about 0.05 mile of concrete base in "exceptions." In addition, a payment of $5,766.91 was made to the Atchison, Topeka & Santa Fe Railroad as the State's share of the cost of an overhead crossing. Also a cattle pass was constructed, but the cost of same was not included in the preliminary estimate.

D–13: The engineer's preliminary estimate was for oiling the concrete base only. In addition to oiling the concrete base, the shoulders were graded and oiled. Portions of the earth shoulders were replaced with gravel. Storm damage increased the cost of the shoulder work. Defective concrete was replaced before oiling, but the cost of same was not included in the preliminary estimate.

D–120: The engineer's preliminary estimate was for 1.42 miles of grading only. The work was extended to cover 3.18 miles and to include the construction of necessary concrete culverts, placing of corrugated metal pipe, and drainage ditches.

APPENDIX C.—MOTOR-VEHICLE LEGISLATION

The present motor vehicle law is known as the California motor vehicle act and is a result of amendments in 1919 to previous legislation. It contains 37 sections. It is administered almost exclusively by the motor-vehicle department with the aid of local police authorities. The State highway department is charged, as previously stated, with the expenditure of one-half the net registration fees, with the granting of special permits to traffic, with the authority to decrease legal load limits, and with the duty of preparing blanks for county officers to report expenditures from the county road funds with respect to the motor-vehicle money returned thereto.

The present law is a development from the experience of preceding years and supersedes legislation of 1905, 1907, 1913, 1915, and 1917. It is understood that plans are now under way through the California Automobile Association in particular to advise amendments to the present law. The evolution of the main provisions of the law is indicated below under the respective headings. There are minute provisions in the law in addition to those summarized below covering the rules of the road and many details found necessary as the automobile traffic has developed, as, for example, use of a mirror when a load obstructs the driver's view to the rear, the passing of slow vehicles proceeding in the same direction, etc. Many of these provisions are obviously the result of experience and are necessary.

The provisions with respect to registration require full data with respect to kind of vehicle and particularly its horsepower, from which the fee is computed; but it would be advantageous to provide that a classification of vehicles registered should result from the total annual registration, so that the numbers of vehicles of all the various capacities and weights could be immediately determined by the State highway department as an aid to future design. It is noteworthy that motor trucks with pneumatic tires are not specifically segregated from other motor vehicles. Accordingly the number of vehicles used in the State for commercial hauling is subject to a corresponding error. Trucks with pneumatic tires are also exempt from restriction with respect to total load per inch width of tire. It is noteworthy that the laws of 1917 and 1919 limit maximum width of loads of loose material to 10 feet.

REGISTRATION AND REVENUE.

The present law requires annual registration on blanks furnished by the motor vehicle department calling for a description of the vehicle. The fee for motor cycles and trailers is $2 and for automobiles 40 cents per horsepower or major fraction, as determined by the formula of the Association of Licensed Automobile Manufacturers. There is a surcharge for every motor vehicle equipped with other than pneumatic tires and used for commercial purposes, as follows: Unladen and under 2 tons weight, $5; unladen and between 2 and 3 tons, $10; unladen and between 3 and 5 tons, $15; unladen and over 5 tons, $20.

The registration fee for electric-motor vehicles is $5 straight, and the above surcharges apply to electric vehicles. Chauffeur's licenses are $2. Of all fees accrued to the motor-vehicle fund, one-half the net revenue is paid to the respective county road funds where originated and the balance is for the use of the State Highway Commission for the repair and improvement of State highways.

The original fee for registration in the act of March 22, 1905, was $2 and annual registration was not required. Any net revenue accrued to the general fund of the State. The amendment of 1907 made no change, but the act of May 13, 1913, provided annual registration, with a graduated fee from $2 for motor cycles to $30 for automobiles exceeding 60 horsepower, and credited to the motor vehicle fund. The act of May 11, 1913, revised the schedule of fees to the present horsepower formula.

SPEEDS AND WEIGHTS.

The present law permits a maximum speed of 35 miles per hour for automobiles outside of incorporated cities and closely built-up sections when the driver has uninterrupted view and nothing ahead for 400 feet, etc., otherwise, 30 miles per hour. In closely built-up sections the legal rate is 20 miles per hour, and where approaching bridges, crossings, bad curves, and intersections it is 10 miles per hour.

There has not been much change in the speed regulations since 1905, except to raise the permissible maximum from 20 miles gradually to 35 miles, and the minimum from 4 to 10 miles, and to redefine the conditions under which the respective speeds are effective.

There is no mention of weight of vehicles until 1917. The law of that year provides that except with special permit in writing from the department of engineering no four-wheel vehicles shall exceed 15 tons gross, and no six-wheel, three-axle vehicle 20 tons, unless such vehicles operate on fixed rails or tracks. In this law also appears for the first time the limitation of 800 pounds per inch width of tire of material other than metal, and of metal 600 pounds, or when the material is part metal except with written permit or in the case of movable trucks (caterpillar engines) as above described. No more than two trailers are allowed.

In this law also, in section 22 (*b*), appears a regulation regarding speed of trucks:

> No motor or other vehicle carrying a weight in excess of 9,000 pounds, including the vehicle, shall be operated, driven, drawn, or otherwise moved on any public highway or bridge at a rate of speed greater than 25 miles an hour; no motor or other vehicle carrying a weight in excess of 12,000 pounds, including the vehicle, shall be operated, driven, drawn, or otherwise moved on any public highway or bridge at a rate of speed greater than 15 miles an hour; no motor or other vehicle carrying a weight in excess of 24,000 pounds, including the vehicle, shall be operated, driven, drawn, or otherwise moved on any public highway or bridge at a rate of speed greater than 6 miles an hour: *Provided further*, That any such motor vehicle or trailer, with tires made wholly or partly of metal, may be operated, driven, drawn, or otherwise moved, subject to the other provisions of this act, up to 10 miles an hour, if

it be equipped with springs and if the rear wheels be not less than 46 inches in diameter, with bearing surface of not less than 18 inches; and provided further, however, anything to the contrary herein notwithstanding, that no motor or other vehicle constructed or otherwise adapted for carrying loads weighing 4 tons or more, exclusive of such vehicle, shall be operated, driven, drawn, or otherwise moved upon the public highway, whether laden or unladen, at a rate of speed exceeding 15 miles an hour; and provided further, that nothing contained in this subdivision shall apply to motor vehicles equipped with pneumatic tires.

The law of 1919 adds a new part to the corresponding subsection as follows:

The supervisors of any county shall have power to require a lighter load on county roads in their respective counties. Any persons violating the provisions of this subsection shall be guilty of a misdemeanor and be liable to a penalty of $20 for each full ton in excess of the limitation herein imposed, and any peace officer making the arrest of the owner or driver of any vehicle violating the provisions of this subsection shall keep said vehicle with its load in his custody until such time as said penalty shall have been paid: *Provided*, That the owner or driver of any such vehicle may give to said peace officer a bond in favor of the State of California in case of State highways, and in the name of the county in which the offense has occurred in the case of county roads, conditioned to secure the payment of said penalty within the time prescribed in said bond. Furthermore, any peace officer may require the driver to drive any such vehicle to the nearest public scale to be designated by such peace officer for the purpose of establishing the weight and the load of any such vehicle.

FLANGES AND CLEATS.

The present law prohibits protuberances of metal or wood in excess of one-fourth inch beyond the traction surface of the tire, except on traction engines operating on unimproved roads.

The use of chains of reasonable proportions is permitted when necessary. Traction engines or tractors with movable tracks may operate even with transverse corrugations under special written permits from the department of engineering (State Highway Commission).

No mention of cleats or chains occurs in the laws until 1913, when the present provisions were inserted, except that they were not made applicable until 1917 to protuberances made of wood.

FOREIGN CARS.

The present law exempts nonresidents in the State of California, when sojourning in the State, from State registration for three months, provided, that the owner applies on a special registration form, without charge, within 24 hours for a distinctive number plate. This was the law in 1917. Previous laws provided that State registration should not be required if the owner displayed his own State number in compliance with the State law. The law of 1913 required the display to be in accordance with the California law and that the plate should be clean and illuminated at night. The law of 1915 provided that foreign corporations doing business in California shall not be exempt from State registration.

LOCAL AUTHORITIES.

The law of 1919 permits local authorities certain jurisdiction with respect to street intersections, crossings, vehicles for hire, processions, etc.; with respect to local cemeteries and with respect to vehicles exceeding 1-ton capacity used exclusively to carry merchandise, which vehicles may be required to use certain one-way streets. The local authorities have otherwise no power to enact ordinances with respect to speed limitations in conflict with the State law. The preceding laws granted local authorities certain jurisdiction with respect to setting aside roads for speed tests and races.

PENALTIES.

The law of 1919 provides general penalties for violations of the provisions of the motor vehicle law with a maximum fine not exceeding $500 or imprisonment not exceeding six months, or both, or for the revocation of the operator's license for a year in addition. The penalties are greater than those of preceding laws. The law of 1905 provided the maximum fine of $100 or imprisonment not exceeding 30 days, or both. The law of 1913 provided for suspension or revocation of the operator's license under certain conditions. The law of 1917 provided that the State highway department should have power to hold hearings and to revoke or suspend licenses of operators for certain violations (through the motor vehicle department) and in certain cases on its own initiative to revoke a license in case of reckless driving or where the operator was concerned in an accident. This provision with respect to the State highway department was not retained in the 1919 law.

APPENDIX D

SELECTED TYPICAL CROSS SECTIONS

SHOWING

LINES OF EQUAL MOISTURE CONTENT IN SUBGRADES

ONE UNIT EQUALS 5 FEET

LEGEND

The cross sections are plotted from levels. The straight lines show borings and are crossed at sample points. The figures on lines of equal moisture show moisture content in per cent.

PLATE LIX.

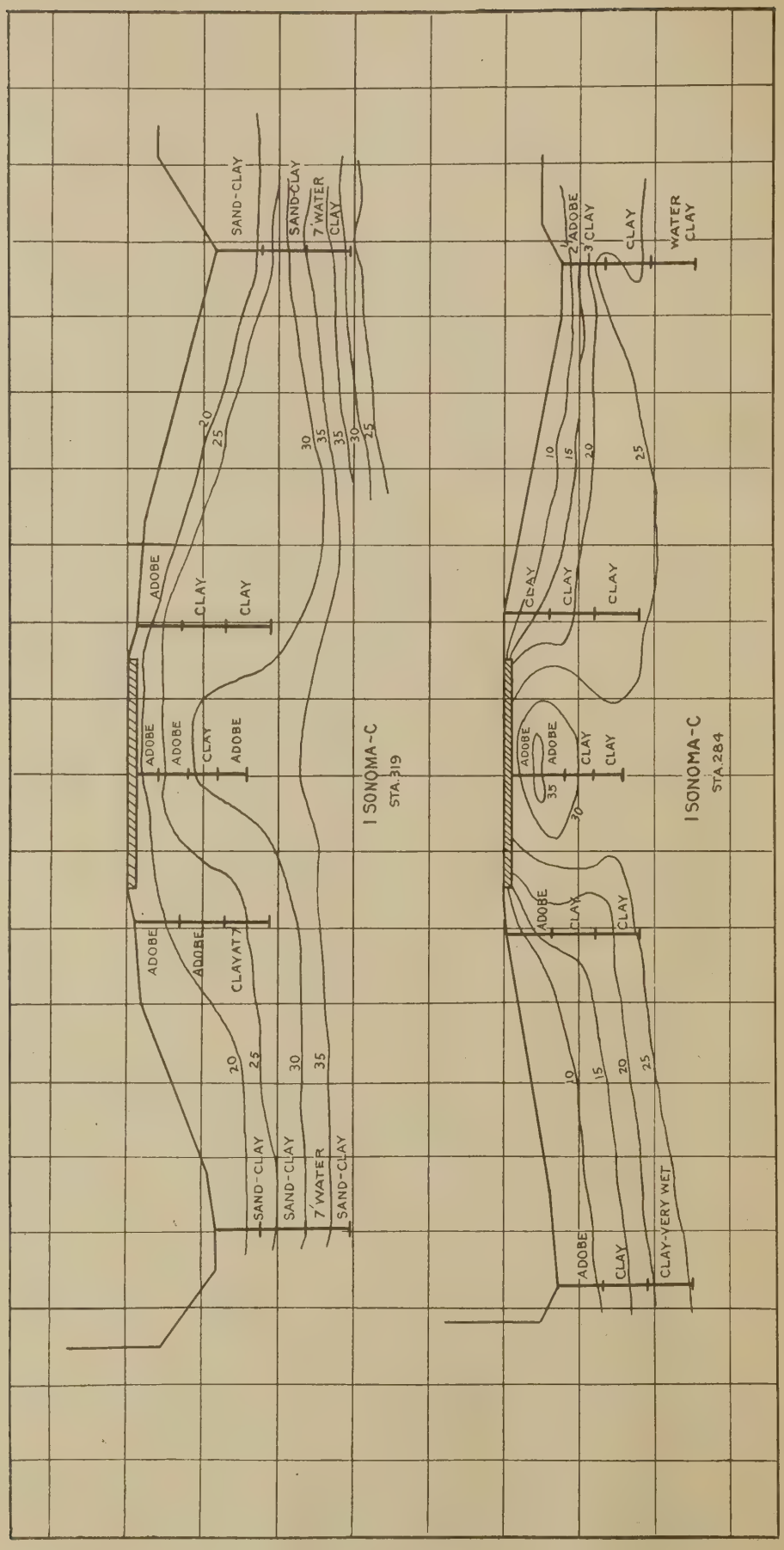

SAND-CLAY
SAND-CLAY
7' WATER
CLAY
ADOBE
CLAY
CLAY
ADOBE
ADOBE
CLAY
ADOBE
ADOBE
ADOBE
CLAY AT 7'
SAND-CLAY
SAND-CLAY
7' WATER
SAND-CLAY
20
25
30
35
35
30
25
20
25
30
35
I SONOMA-C
STA. 319
2 ADOBE
3 CLAY
CLAY
WATER
CLAY
CLAY
CLAY
CLAY
ADOBE
ADOBE
CLAY
CLAY
ADOBE
CLAY
CLAY
ADOBE
CLAY
CLAY-VERY WET
10
15
20
25
35
30
10
15
20
25
I SONOMA-C
STA. 284

PLATE LX.

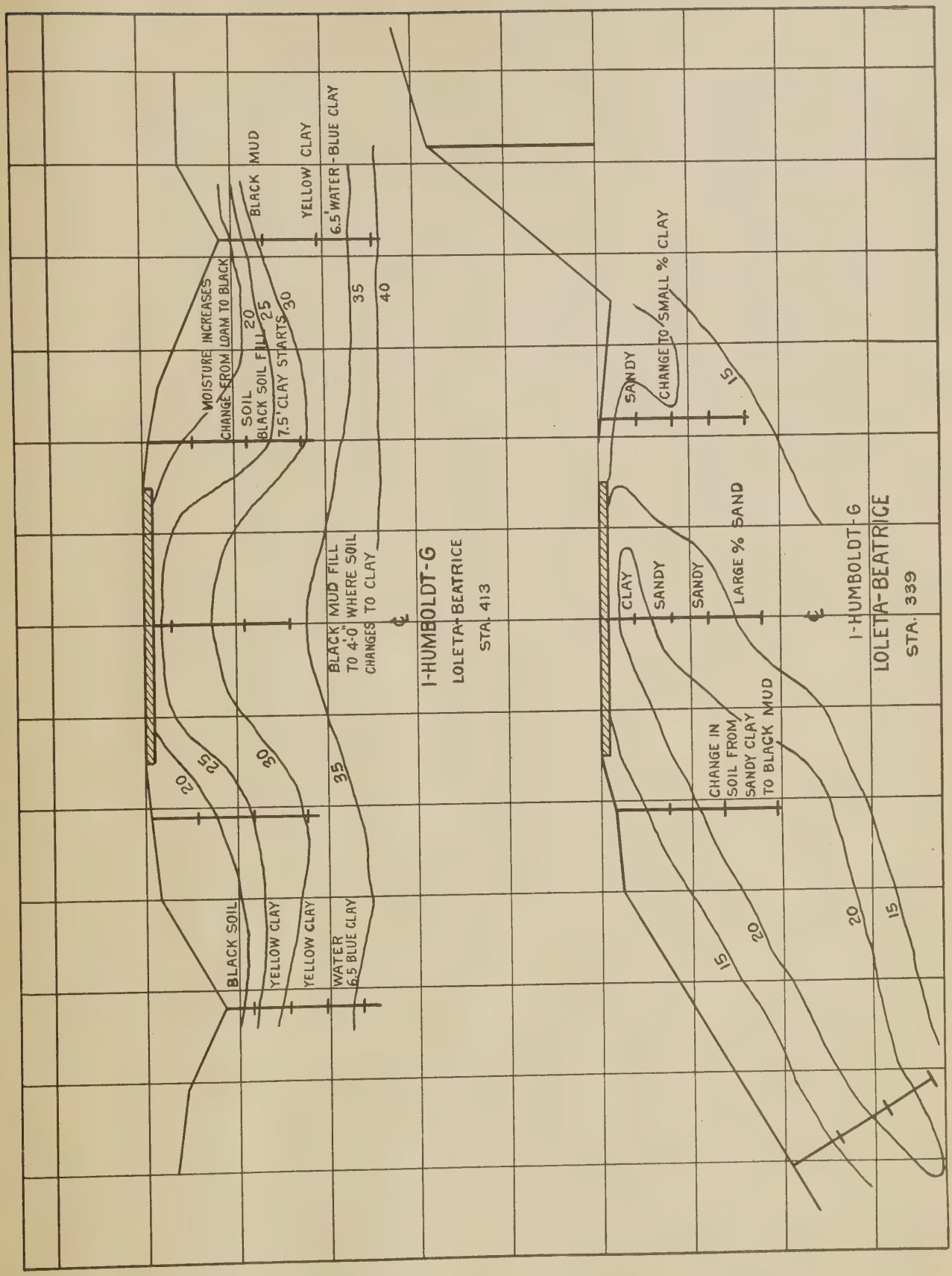

BLACK SOIL
YELLOW CLAY
YELLOW CLAY
WATER
6.5 BLUE CLAY
20
25
30
35
BLACK MUD FILL
TO 4'-0" WHERE SOIL
CHANGES TO CLAY
1-HUMBOLDT-G
LOLETA-BEATRICE
STA. 413
MOISTURE INCREASES
CHANGE FROM LOAM TO BLACK
SOIL
BLACK SOIL FILL
7.5' CLAY STARTS
BLACK MUD
YELLOW CLAY
6.5' WATER-BLUE CLAY
20
25
30
35
40
CLAY
SANDY
SANDY
LARGE % SAND
SANDY
CHANGE TO SMALL % CLAY
15
CHANGE IN
SOIL FROM
SANDY CLAY
TO BLACK MUD
15
20
20
15
1-HUMBOLDT-G
LOLETA-BEATRICE
STA. 339

PLATE LXI.

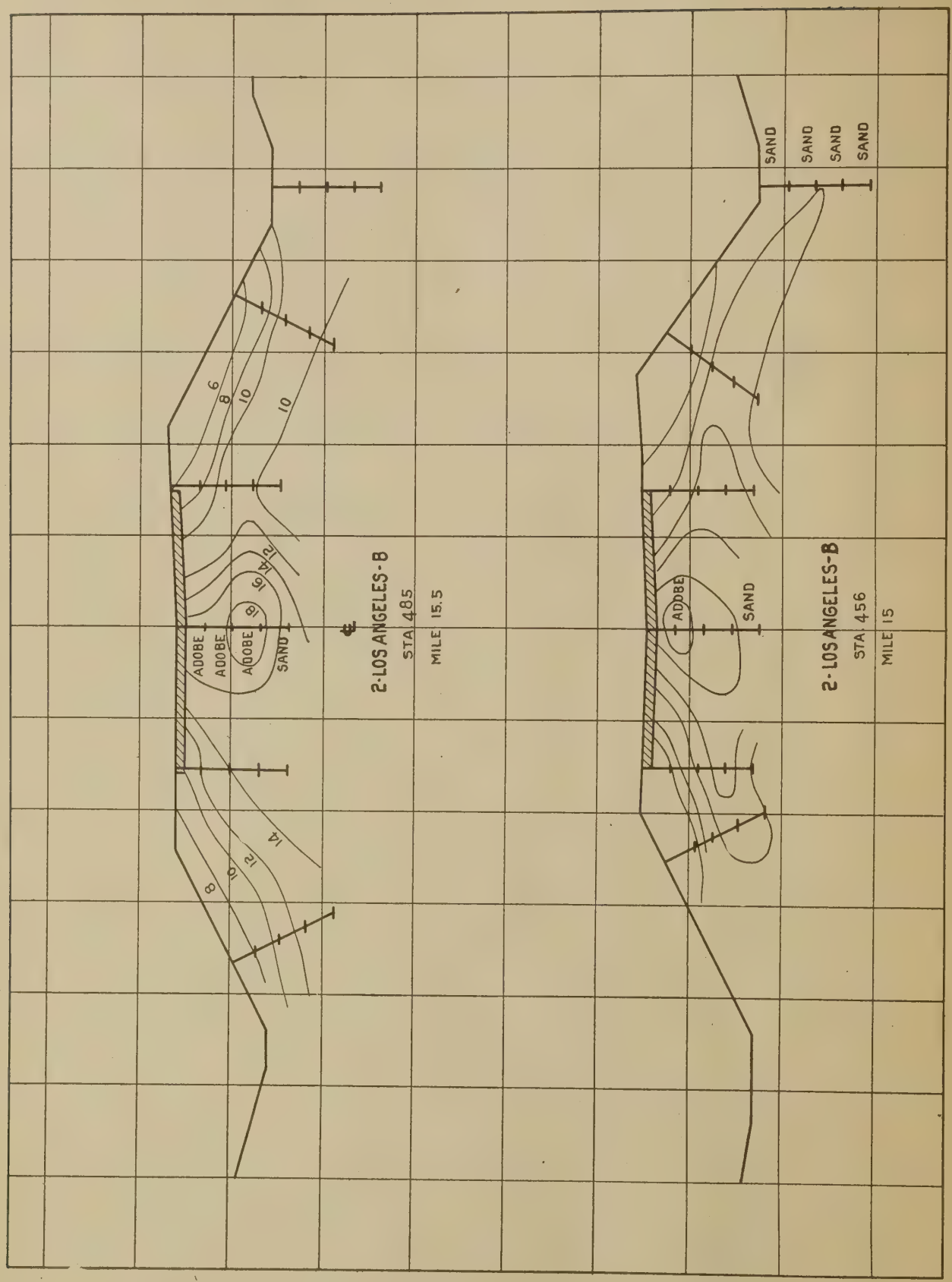
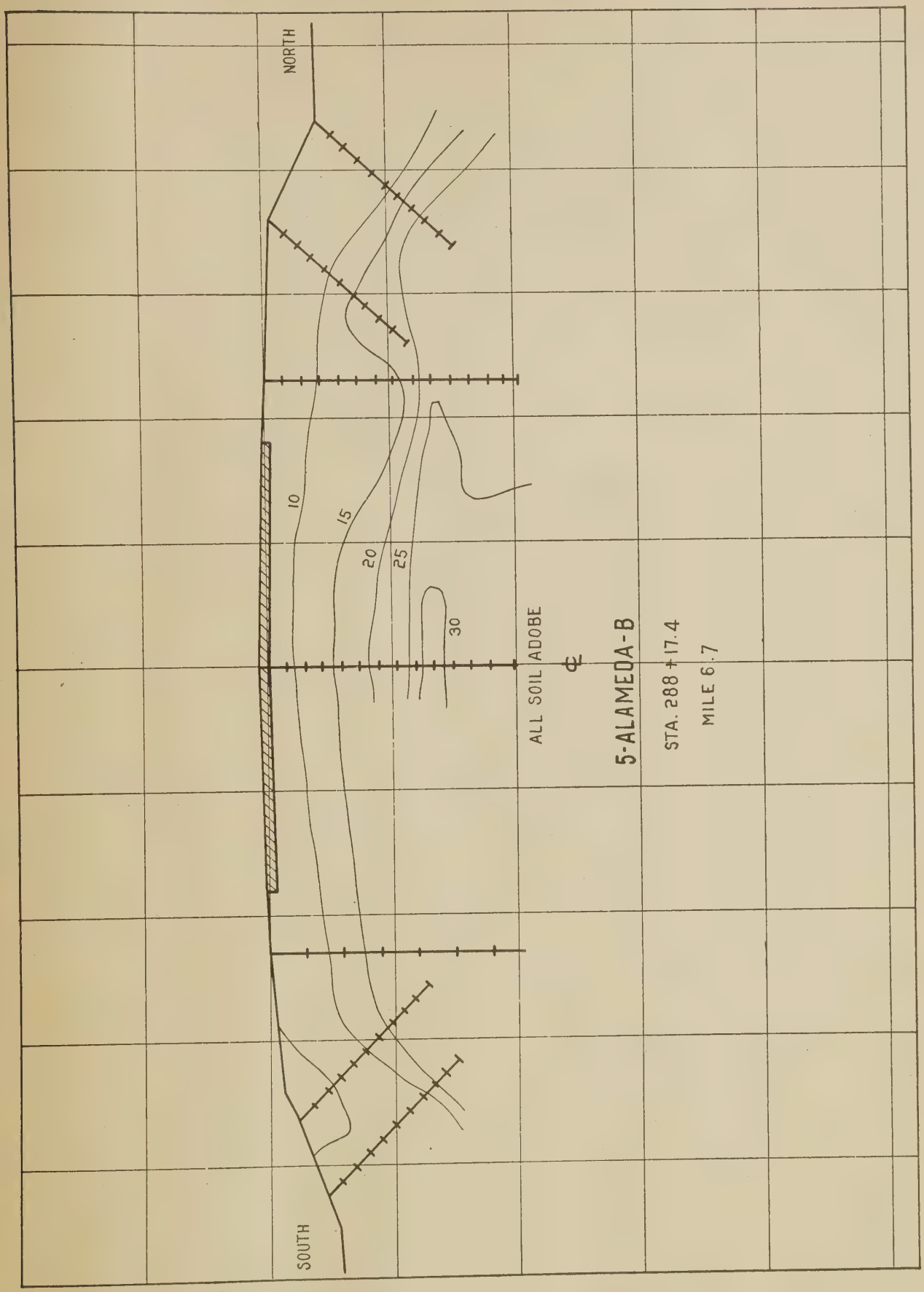

SAND
SAND
SAND
SAND
ADOBE
SAND
2-LOS ANGELES-B
STA. 456
MILE 15
6
8
10
10
ADOBE
ADOBE
ADOBE
SAND
2-LOS ANGELES-B
STA. 485
MILE 15.5

PLATE LXII.



75712—22——10

PLATE LXIII.

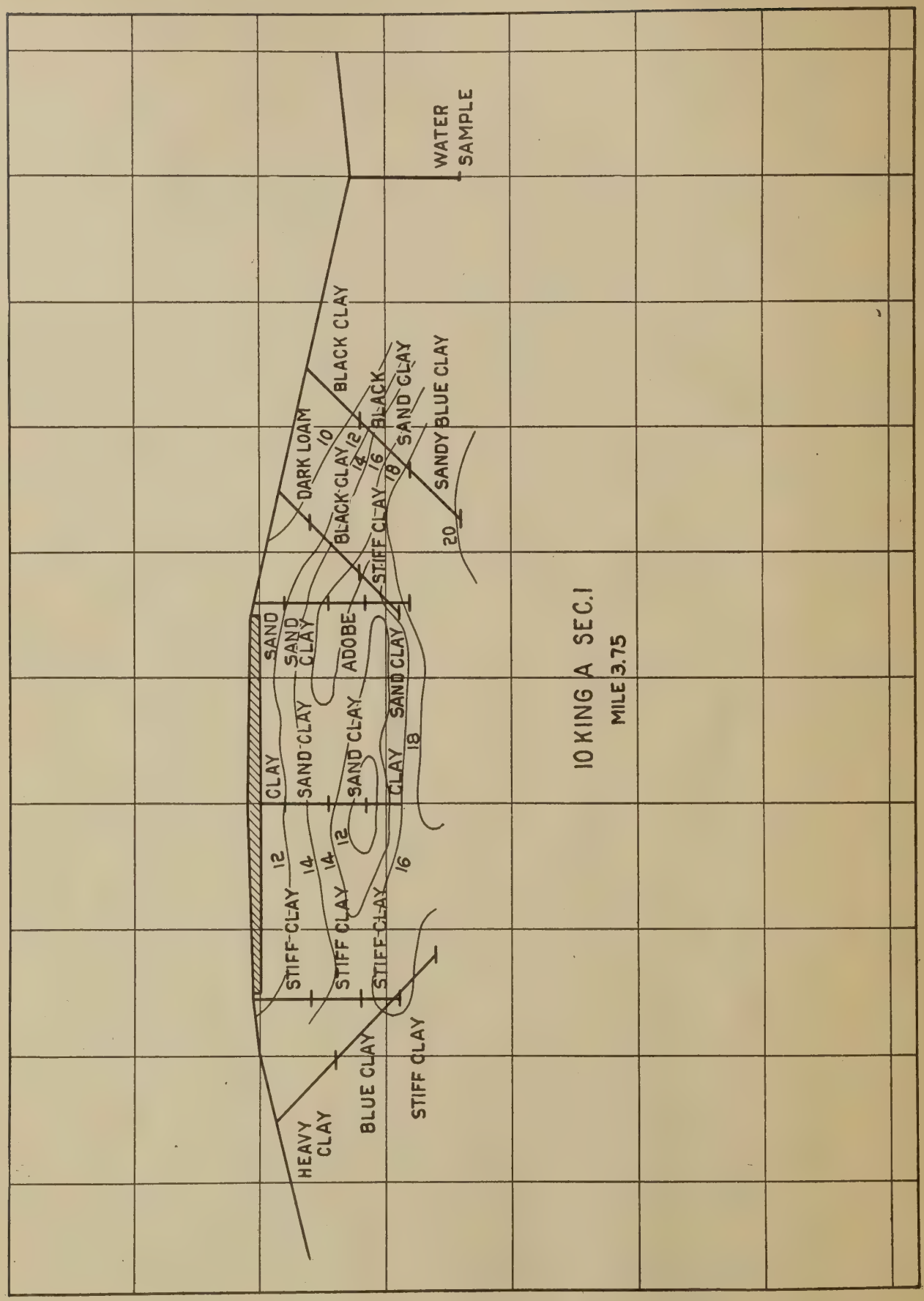
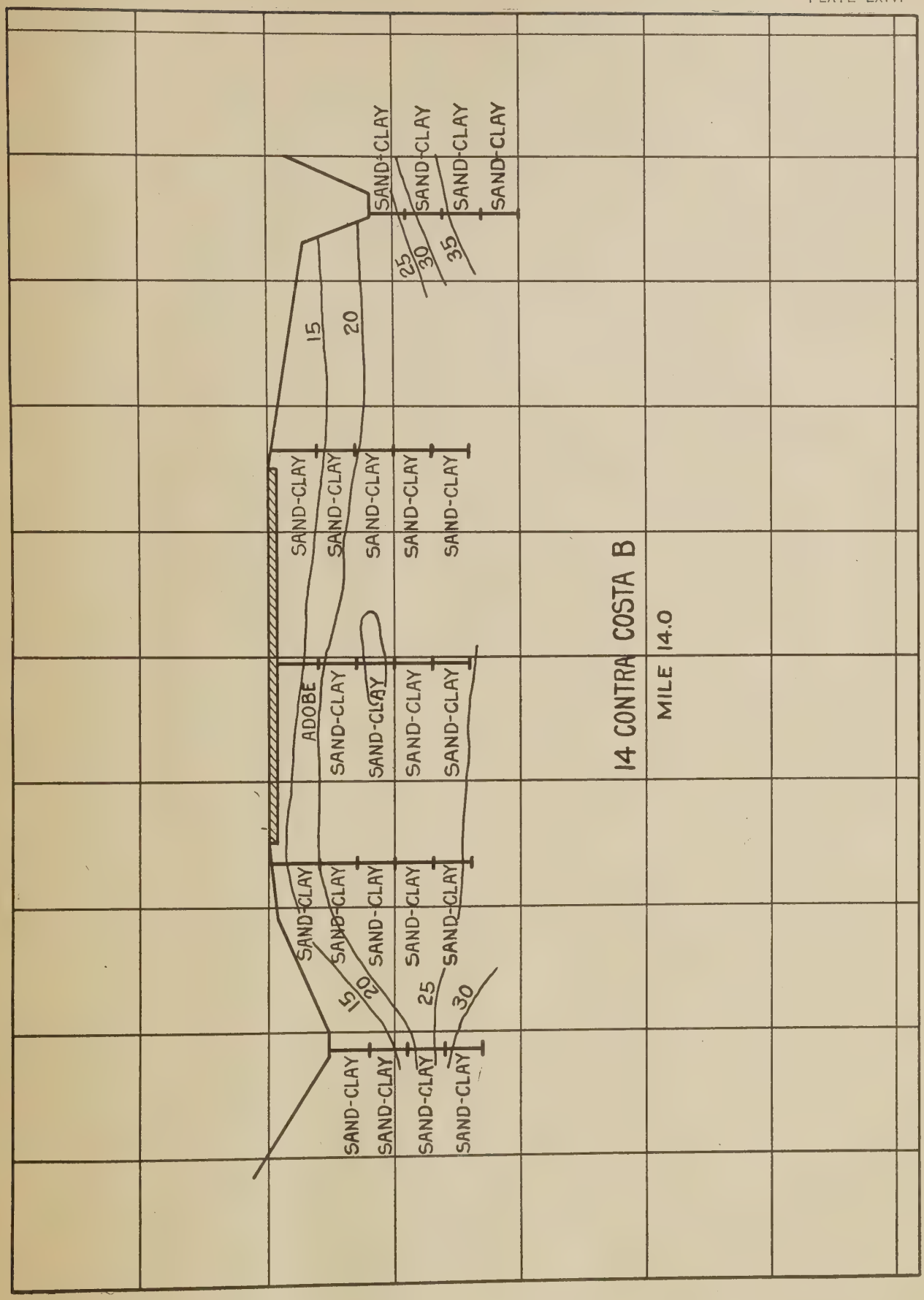

WATER SAMPLE
BLACK CLAY
DARK LOAM
BLACK CLAY
BLACK
SAND CLAY
SANDY BLUE CLAY
STIFF CLAY
SAND
SAND CLAY
ADOBE
SAND CLAY
CLAY
SAND CLAY
STIFF CLAY
STIFF CLAY
STIFF CLAY
BLUE CLAY
HEAVY CLAY
STIFF CLAY
10
12
14
16
18
20
10 KING A SEC. 1
MILE 3.75

PLATE LXIV.



APPENDIX E.—TRAFFIC BLANK

STATE.....

TRAFFIC RECORD

SIGNED.....

ROUTE NO..... TRAFFIC STATION NO..... AT..... DATE..... CLOCK INTERVAL..... WEATHER.....

KIND OF VEHICLES	TIME TO	TIME TO	TIME TO	TIME TO	TIME TO	TIME TO	TIME TO	TIME TO	TOTAL
LIGHT AUTOMOBILES									
HEAVY AUTOMOBILES									
BUSSES									
TRUCKS LESS THAN 1 TON, PNEUMATIC TIRES AND LESS THAN ¾ TON SOLID TIRES.									
TRUCKS 1 TO 2½ TONS WITH PNEUMATIC TIRES, ¾ TO 1½ TONS, SOLID TIRES.									
TRUCKS 3 TO 5 TONS, WITH PNEUMATICS; 2 TO 3 TONS WITH SOLID TIRES.									
TRUCKS 5 TONS PLUS, PNEUMATICS, 3 TONS PLUS, SOLID.									
HORSE DRAWN VEHICLES.									
EXTRA HEAVY VEHICLES.									
REMARKS									

APPENDIX F.—MOTOR TRUCK FREIGHT LINES

The motor freight transportation business is well systematized. The membership of the California State Draymen's Association, organized April 19, 1919, in November, 1920, included 80 per cent of the commercial hauling concerns operating under State railroad commission license, and representing 90 per cent of the vehicles used for this purpose. An outgrowth of this State organization was a national organization of similar interests perfected in June, 1920, at Chicago, with one of the California association officers as general manager.

The California organization has 30 affiliated and subsidiary county and district associations through which it operates. Its purpose is the promotion and protection of the motor trucking business through propaganda and suitable legislation. To this end it is studying the use of the motor-truck transportation for raw and finished products, the production and distribution of which it is now investigating. It is also preparing to fight any adverse legislation at the coming session of the State legislature.

The rates of licensed truck companies are subject to approval by the State railroad commission.

Few companies operate on a flat charge per ton-mile. Their tariffs are based on commodity classes somewhat similar to those of the railroads, and the charge is adjusted on the basis of hundredweight-miles. Many fix a minimum charge for handling parcels. Both local and through tariffs are used. Local tariffs frequently apply to a territory and are not computed strictly on a mileage basis. In many instances the service includes house-door collection and delivery, but a number of companies transport only between their several storage places. Some of the latter make local delivery for a fee, while others require the consignee to arrange for such service.

Commercial hauling under supervision of the railroad commission is only a small part of that done. To avoid the restrictions imposed by the commission for common carriers and to obviate the delays of public hearings in regard to extensions of route, changes of schedule, etc., many operators organize their business as a contract haul. Agreements require delivery along certain routes or between fixed termini, either for fixed or indeterminate periods. In this way not only interurban trucking but transportation of fruits, vegetables, dairy products, and grain from farm to canneries, depots, creameries, etc., is done. In the southern part of the State quite a number of routes are established to haul to market all agricultural products grown on certain farms and to deliver merchandise, feed, etc. The fruit and grain crops of the north are handled almost entirely by outside trucks, which move from section to section with the ripening of crops. (The standard charge for handling this season's rice crop was 25 cents per ton-mile.) It is estimated that not less than 4,000 trucks are used in California for contract hauling for entire or part time throughout the year.

In order to arrived at a weighted approximate average through rate per ton-mile, the estimated gross receipts per week from 48 lines were divided by the ton-miles involved in the estimated tonnage handled between termini. There were 122,765 ton-miles of service rendered at a total charge of $25,535.85, making the cost 20.8 cents per ton-mile. These lines traverse practically all the paved State highways, as well as lateral roads, both State and county.[31]

[31] Some of the extreme average rates found by this method of calculation but regarded as not very reliable are the following:

PART PAVED STATE HIGHWAY, PART UNPAVED.

	Mile haul.	Per ton-mile.
High—	17	$1.54
	20	.95
	15	.80
	38	.69

ENTIRELY PAVED.

Low—	126	$0.03
	130	.06
	126	.07
	27	.15

APPENDIX G

TRAFFIC DIAGRAMS

INDICATING

16-HOUR-DAY TRAFFIC ON CALIFORNIA STATE HIGHWAYS

LEGEND

The curves show the total of all vehicles, the total of going and of coming vehicles, the total of automobiles and the total trucks all plotted to a vertical scale of 500 vehicles to the unit and a horizontal scale of 20 miles to the unit.

PLATE LXVI.

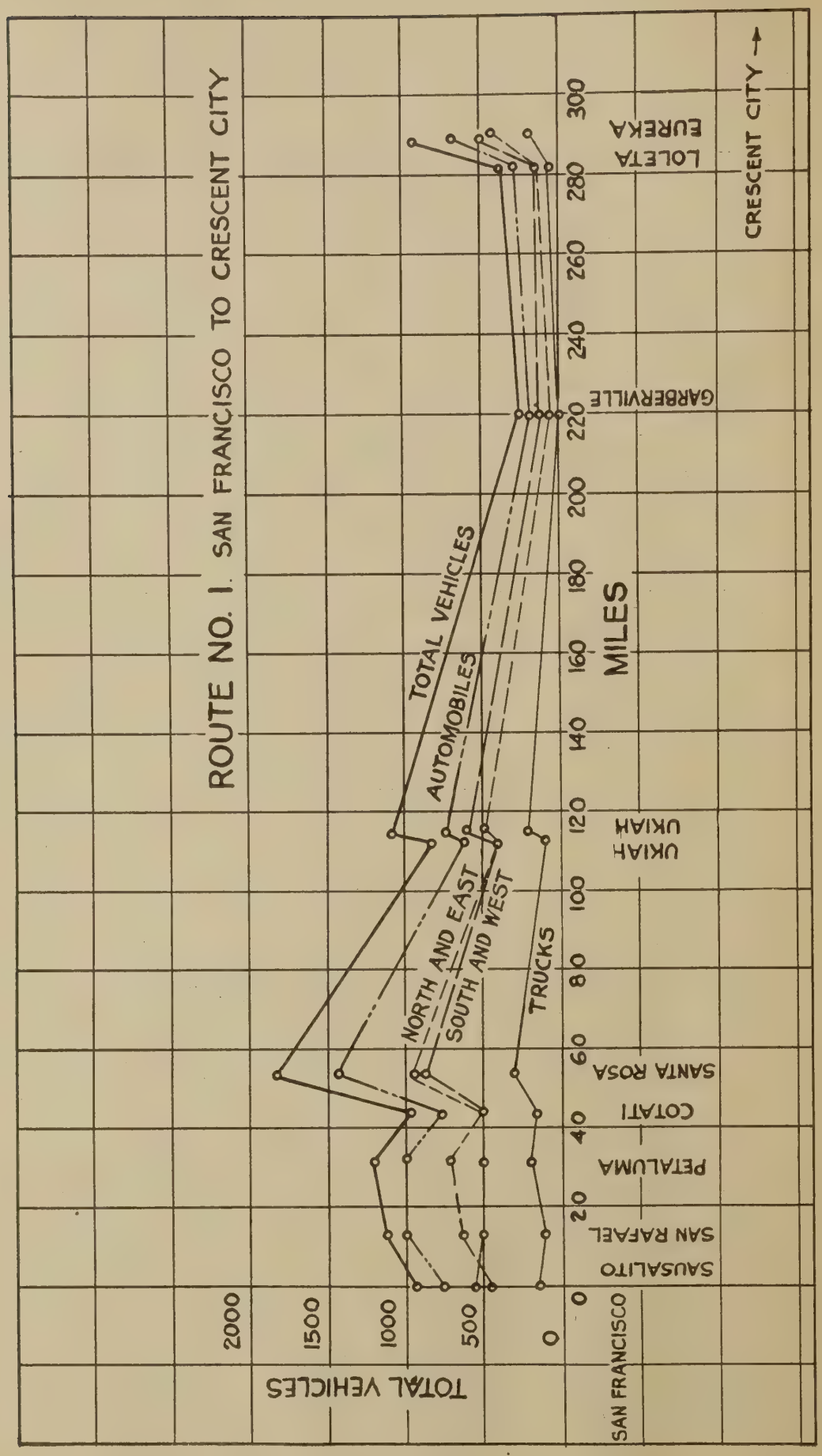

ROUTE NO. 1. SAN FRANCISCO TO CRESCENT CITY
TOTAL VEHICLES
2000
1500
1000
500
0
SAN FRANCISCO
SAUSALITO
SAN RAFAEL
PETALUMA
COTATI
SANTA ROSA
UKIAH
UKIAH
GARBERVILLE
LOLETA
EUREKA
CRESCENT CITY
MILES
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
TOTAL VEHICLES
AUTOMOBILES
NORTH AND EAST
SOUTH AND WEST
TRUCKS

PLATE LXVII.

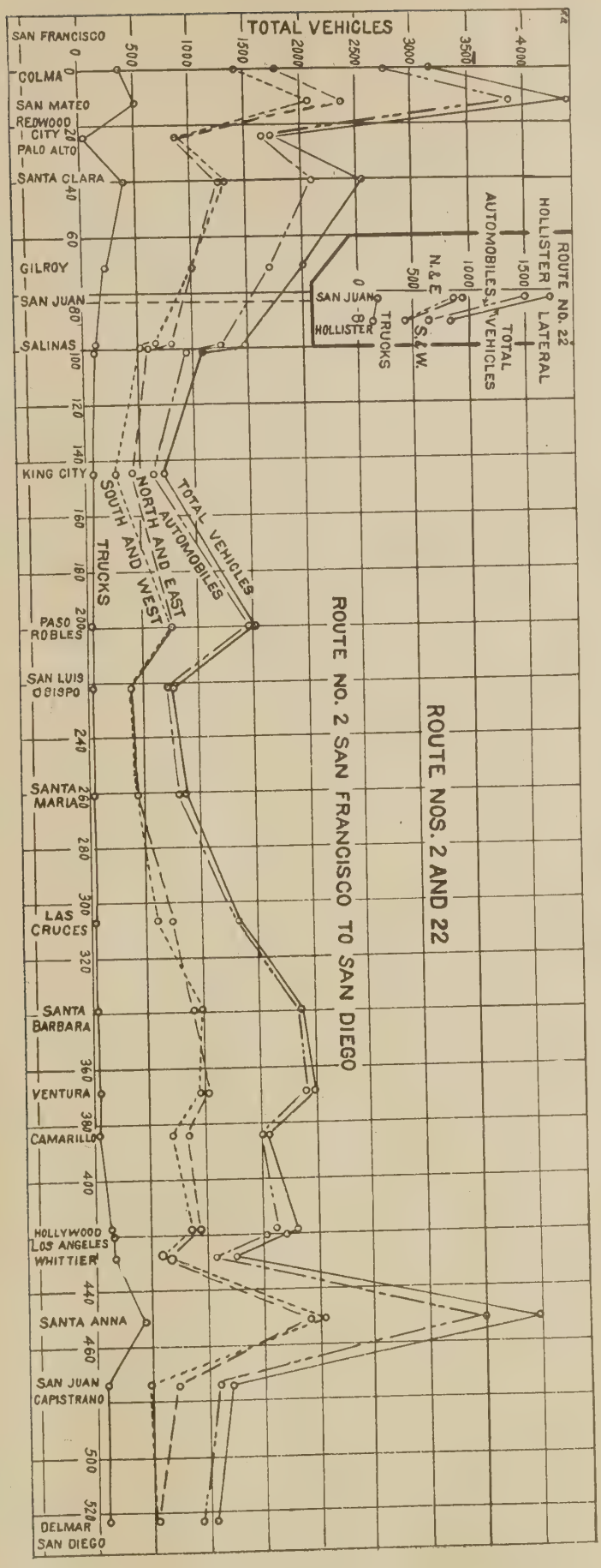

TOTAL VEHICLES
SAN FRANCISCO
COLMA
SAN MATEO
REDWOOD CITY
PALO ALTO
SANTA CLARA
GILROY
SAN JUAN
SALINAS
KING CITY
PASO ROBLES
SAN LUIS OBISPO
SANTA MARIA
LAS CRUCES
SANTA BARBARA
VENTURA
CAMARILLO
HOLLYWOOD
LOS ANGELES
WHITTIER
SANTA ANNA
SAN JUAN CAPISTRANO
DELMAR
SAN DIEGO
ROUTE NO. 22
HOLLISTER
LATERAL
AUTOMOBILES
TOTAL VEHICLES
SAN JUAN
HOLLISTER
TRUCKS
N. & E.
S. & W.
TOTAL VEHICLES
AUTOMOBILES
NORTH AND EAST
SOUTH AND WEST
TRUCKS
ROUTE NO. 2 SAN FRANCISCO TO SAN DIEGO
ROUTE NOS. 2 AND 22

PLATE LXVIII.

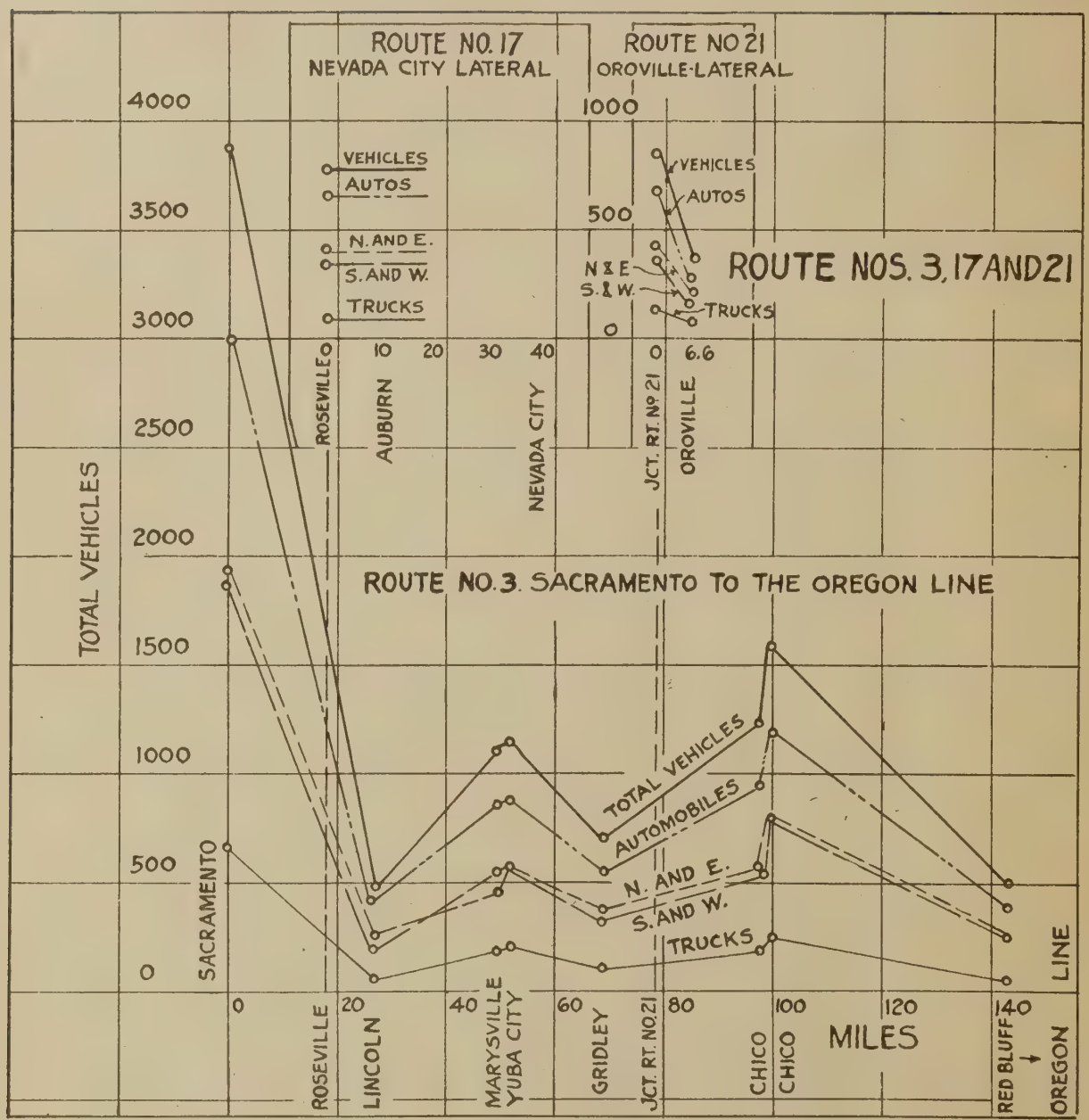


PLATE LXIX.

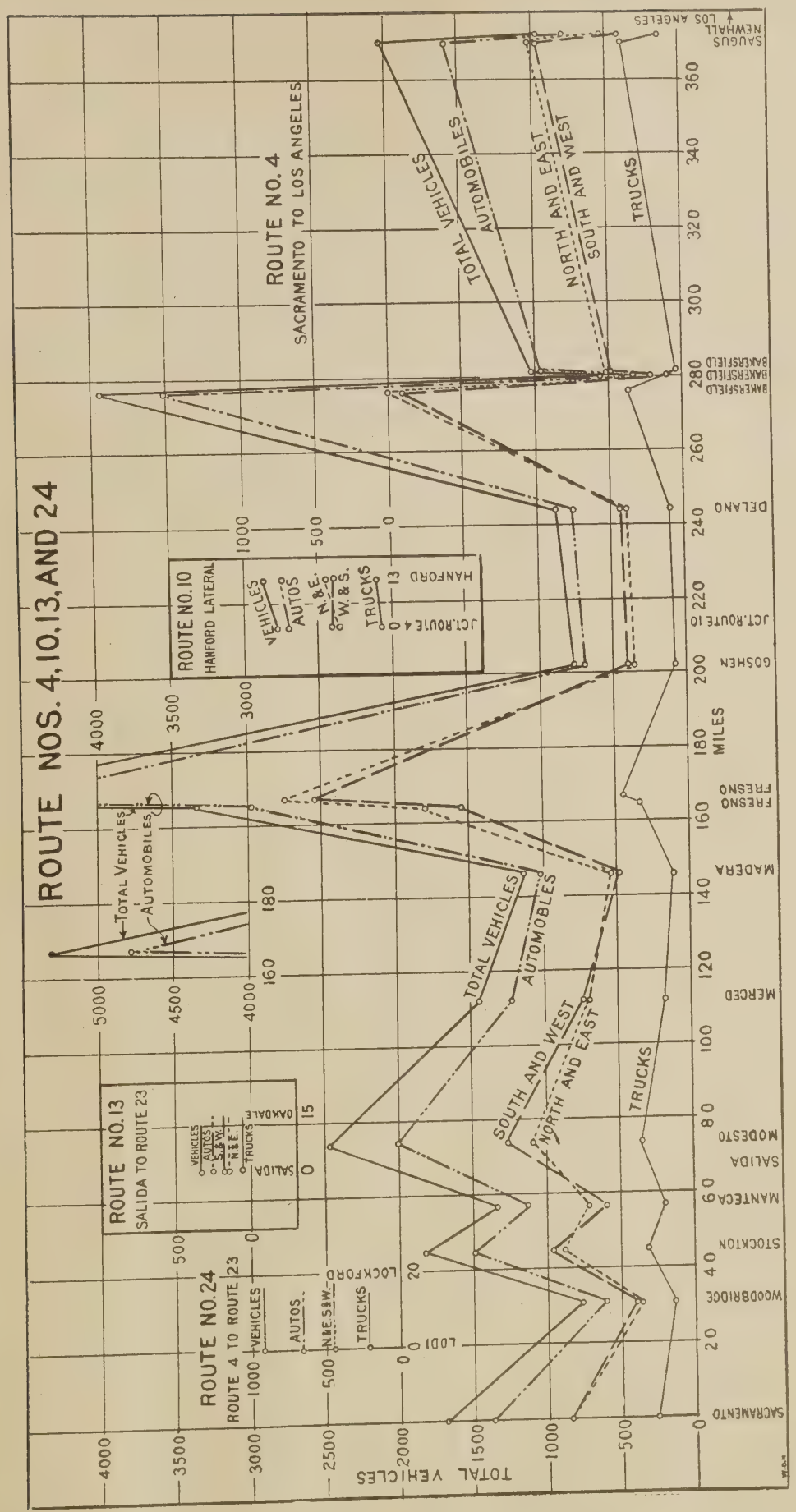

ROUTE NOS. 4, 10, 13, AND 24
ROUTE NO. 4
SACRAMENTO TO LOS ANGELES
TOTAL VEHICLES
TOTAL AUTOMOBILES
NORTH AND EAST
SOUTH AND WEST
TRUCKS
ROUTE NO. 10
HANFORD LATERAL
VEHICLES
AUTOS
N. & E.
W. & S.
TRUCKS
JCT. ROUTE 4
HANFORD
ROUTE NO. 13
SALIDA TO ROUTE 23
VEHICLES
AUTOS
S. & W.
N. & E.
TRUCKS
SALIDA
OAKDALE
ROUTE NO. 24
ROUTE 4 TO ROUTE 23
VEHICLES
AUTOS.
N. & E. S. & W.
TRUCKS
LOCKFORD
LODI
TOTAL VEHICLES
MILES
SACRAMENTO
WOODBRIDGE
STOCKTON
MANTECA
SALIDA
MODESTO
MERCED
MADERA
FRESNO
GOSHEN
JCT. ROUTE 10
DELANO
BAKERSFIELD
SAUGUS
NEWHALL
LOS ANGELES

PLATE LXX.

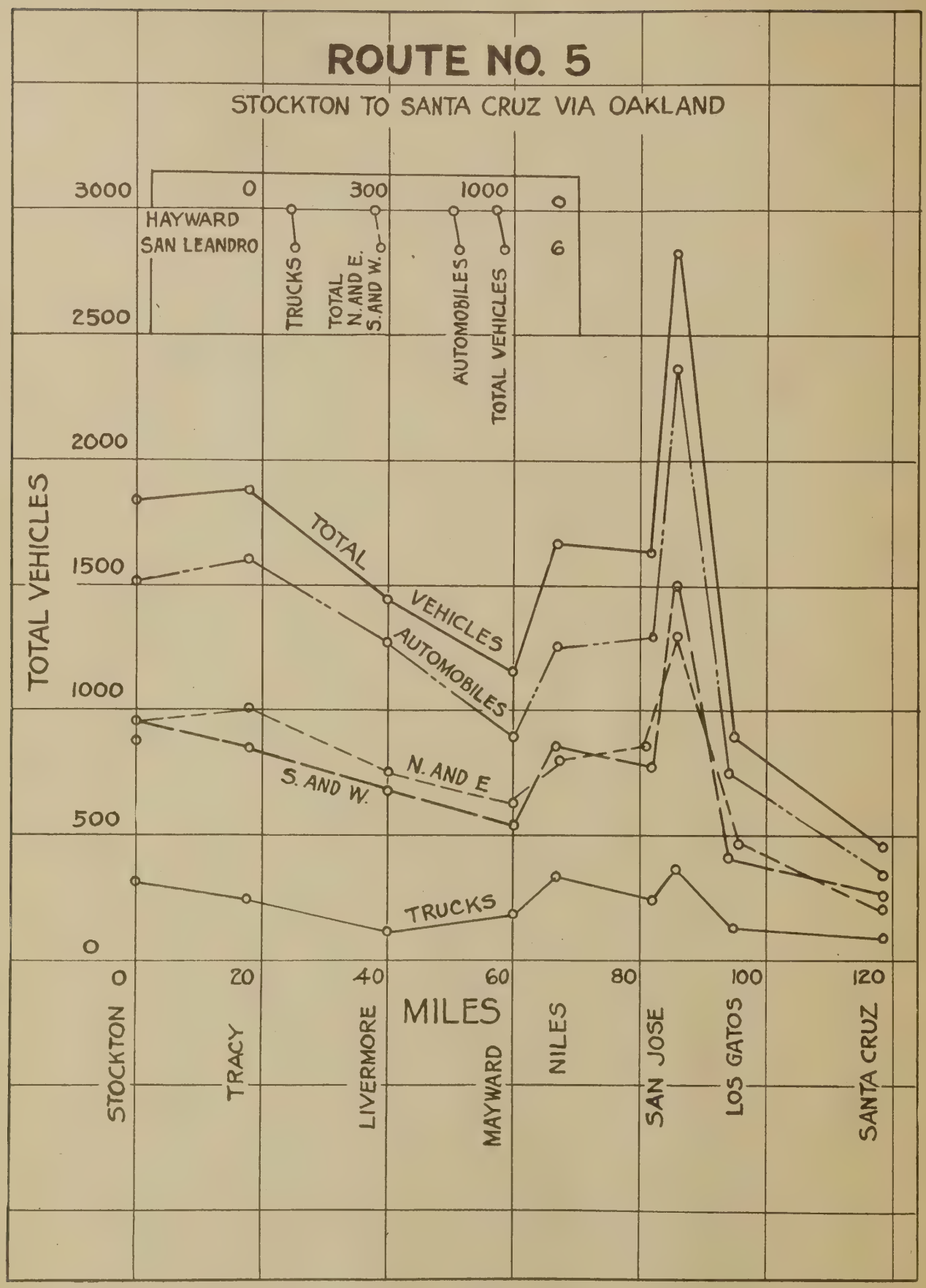

ROUTE NO. 5
STOCKTON TO SANTA CRUZ VIA OAKLAND
3000
2500
2000
1500
1000
500
0
TOTAL VEHICLES
0
300
1000
0
6
0
HAYWARD
SAN LEANDRO
TRUCKS
TOTAL N. AND E. S. AND W.
AUTOMOBILES
TOTAL VEHICLES
TOTAL
VEHICLES
AUTOMOBILES
N. AND E
S. AND W.
TRUCKS
0
20
40
60
80
100
120
MILES
STOCKTON
TRACY
LIVERMORE
MAYWARD
NILES
SAN JOSE
LOS GATOS
SANTA CRUZ

PLATE LXXI.

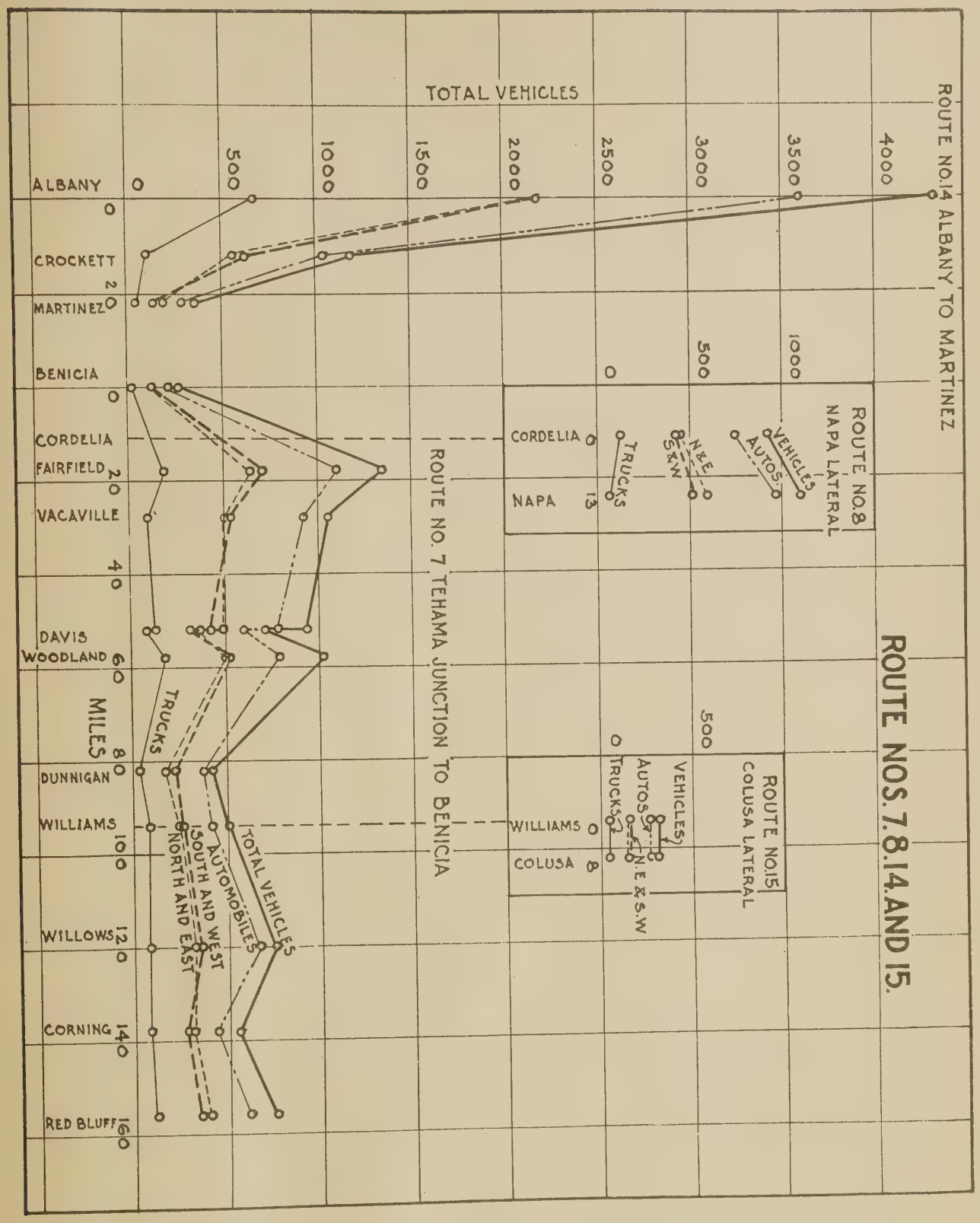
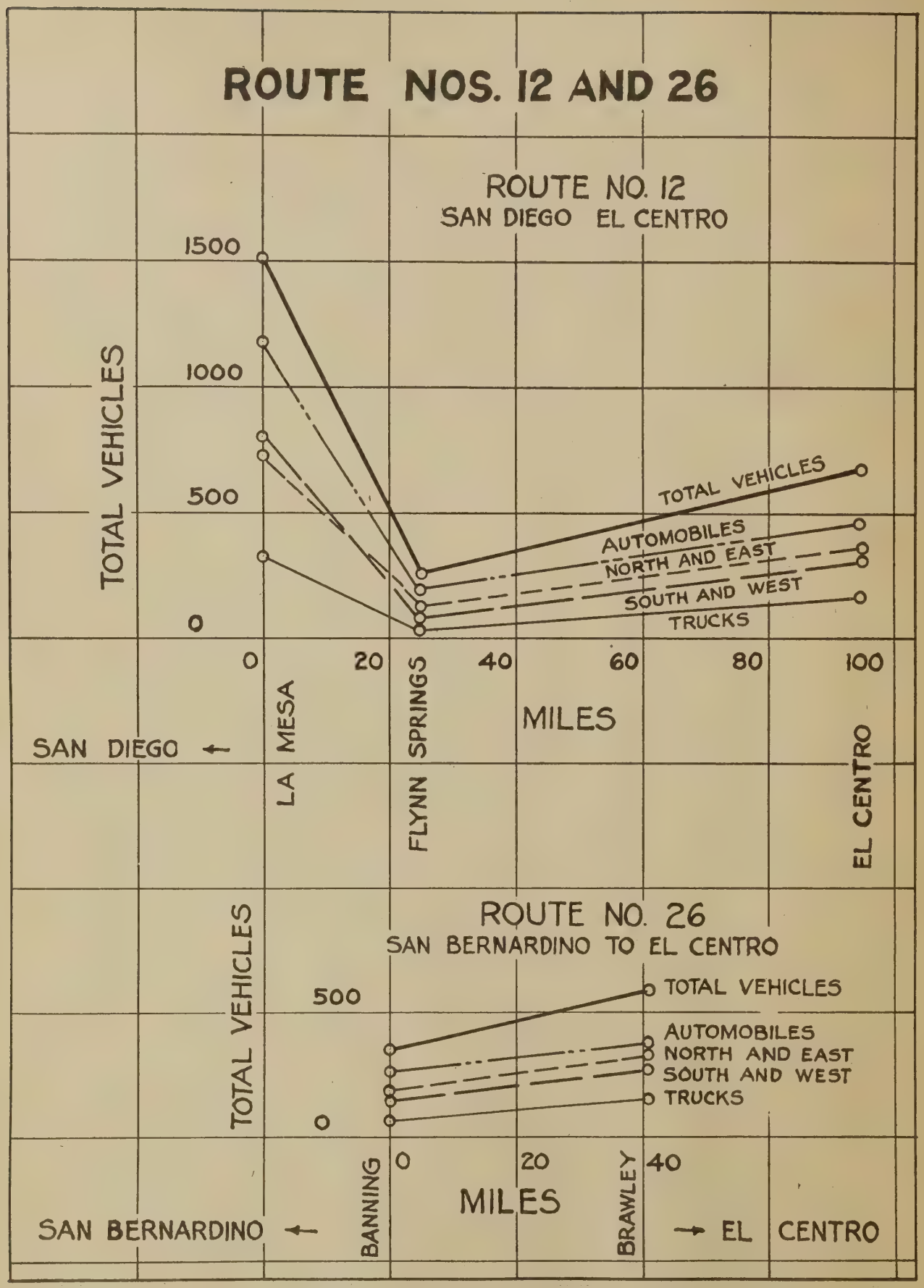

ROUTE NOS. 7.8.14. AND 15.
ROUTE NO.14 ALBANY TO MARTINEZ
ROUTE NO. 7 TEHAMA JUNCTION TO BENICIA
ROUTE NO.8 NAPA LATERAL
ROUTE NO.15 COLUSA LATERAL
TOTAL VEHICLES
MILES
ALBANY
CROCKETT
MARTINEZ
BENICIA
CORDELIA
FAIRFIELD
VACAVILLE
DAVIS
WOODLAND
DUNNIGAN
WILLIAMS
WILLOWS
CORNING
RED BLUFF
NAPA
COLUSA
VEHICLES
AUTOS
TRUCKS
N. & E. & S. & W.
AUTOMOBILES
TOTAL VEHICLES
SOUTH AND WEST
NORTH AND EAST

PLATE LXXII.


ROUTE NOS. 12 AND 26
ROUTE NO. 12
SAN DIEGO EL CENTRO
TOTAL VEHICLES
1500
1000
500
0
TOTAL VEHICLES
AUTOMOBILES
NORTH AND EAST
SOUTH AND WEST
TRUCKS
0
20
40
60
80
100
MILES
SAN DIEGO
LA MESA
FLYNN SPRINGS
EL CENTRO
ROUTE NO. 26
SAN BERNARDINO TO EL CENTRO
TOTAL VEHICLES
500
0
TOTAL VEHICLES
AUTOMOBILES
NORTH AND EAST
SOUTH AND WEST
TRUCKS
0
20
40
MILES
SAN BERNARDINO
BANNING
BRAWLEY
EL CENTRO

APPENDIX H

DIAGRAMS SHOWING

CLASS CONDITION OF CONCRETE PAVEMENT

CALIFORNIA STATE HIGHWAYS

BY ROUTES, COUNTIES, AND SECTIONS

LEGEND

HORIZONTAL SCALE: 1 UNIT = 2 MILES

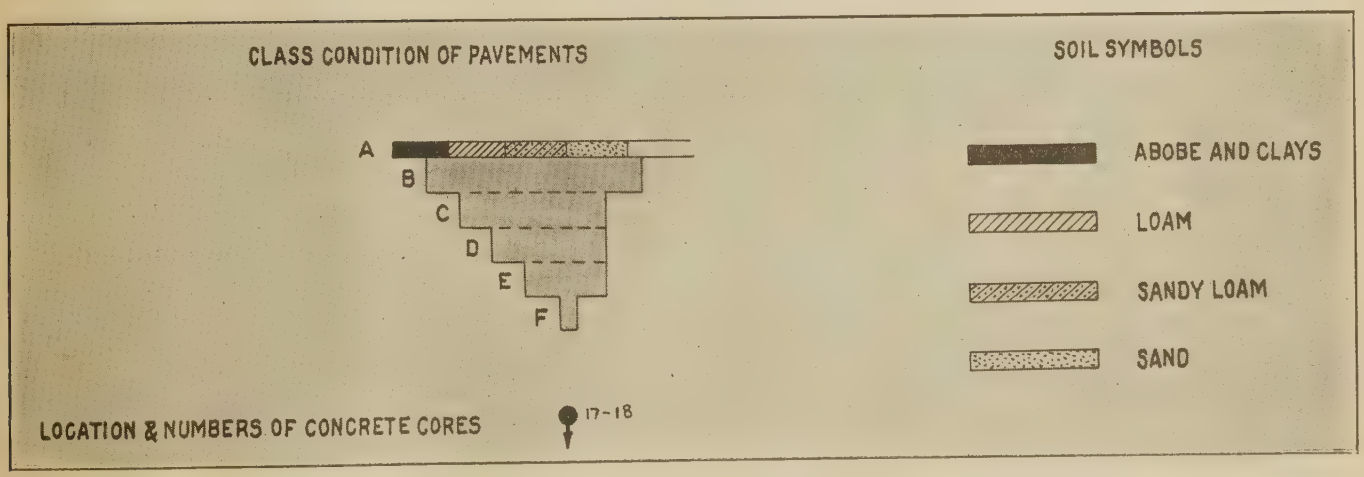


PLATE LXXIII.

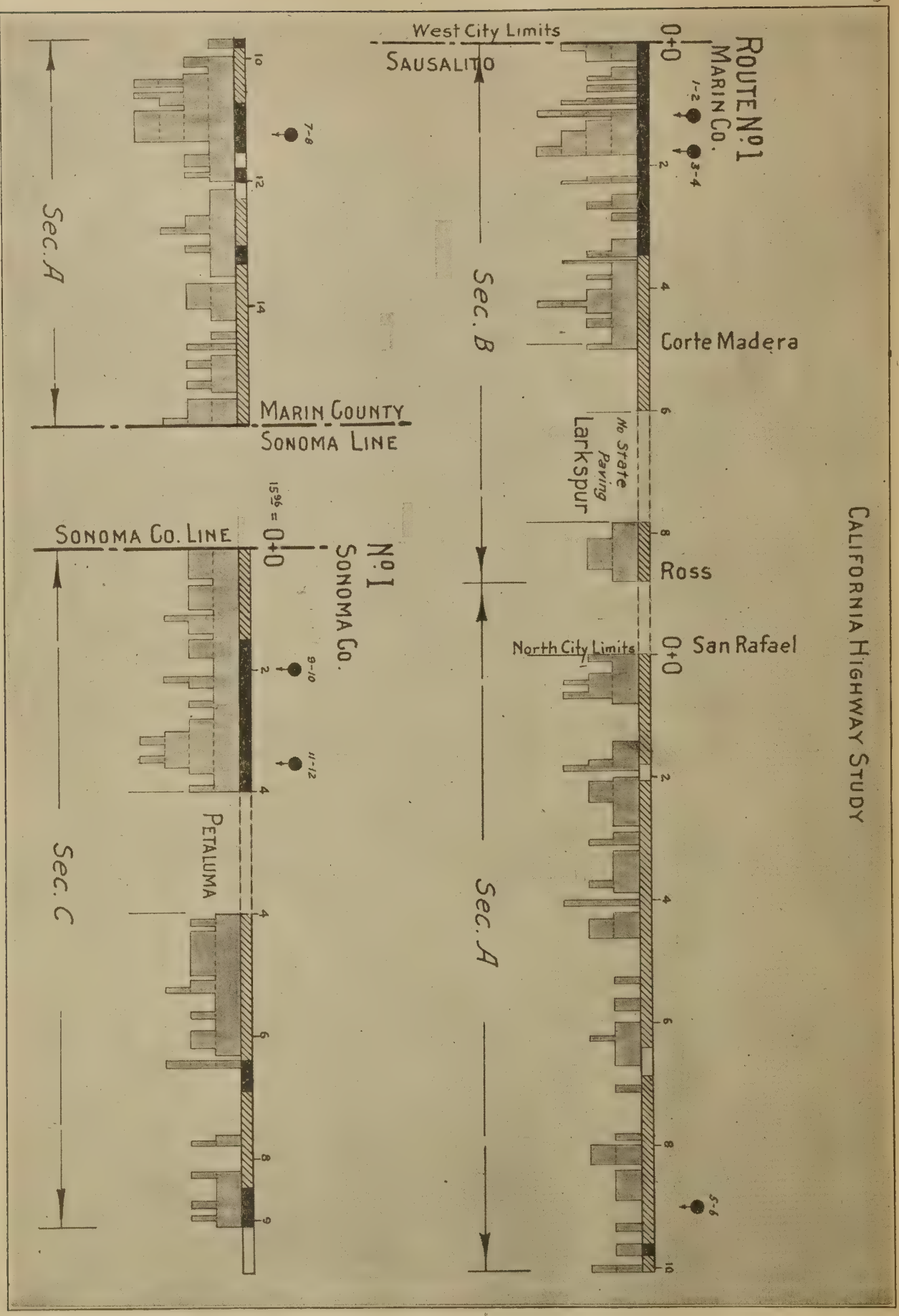
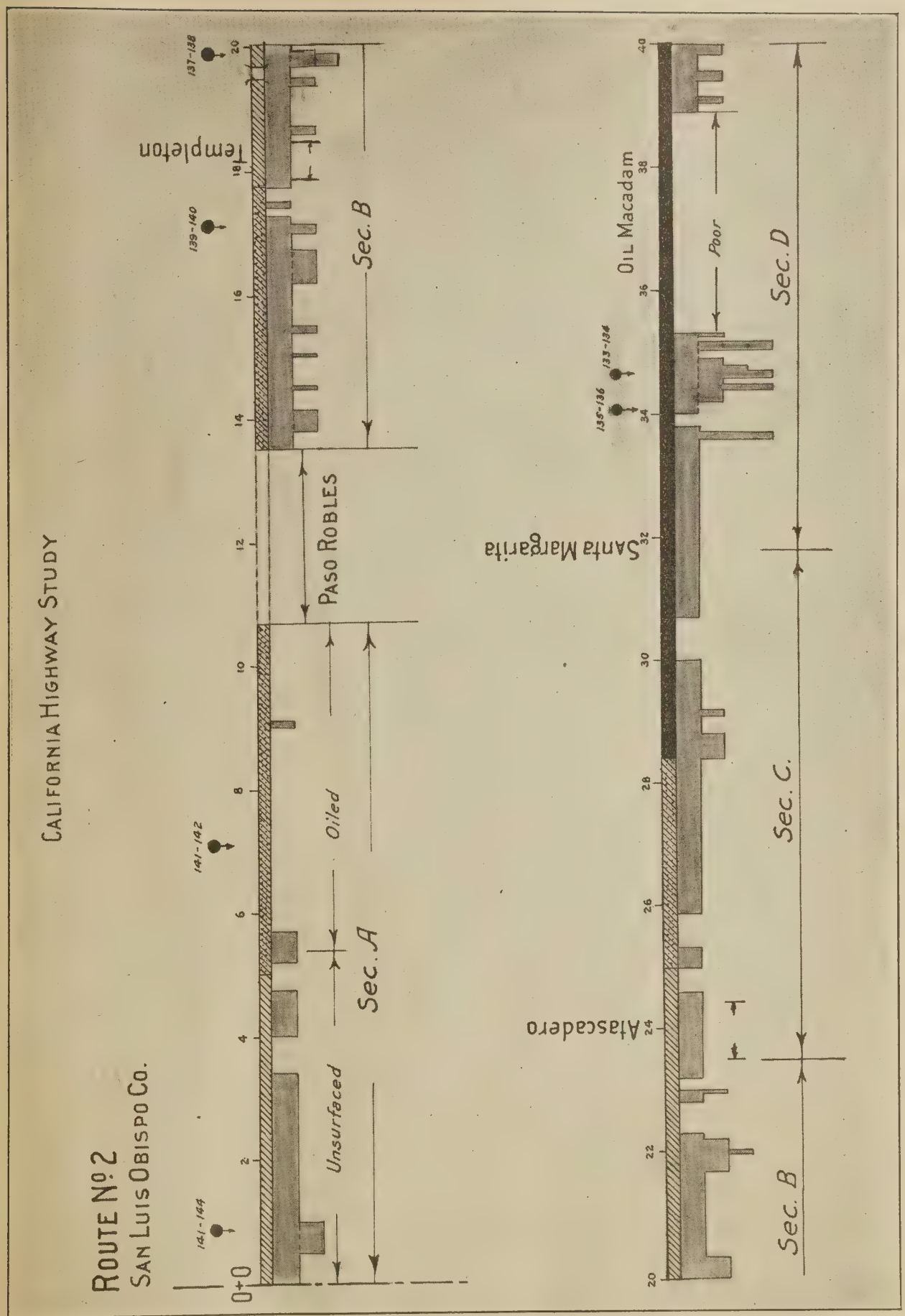


PLATE LXXIV.


California Highway Study
Route No. 2
San Luis Obispo Co.
0+0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
141-144
141-142
139-140
137-138
133-134
135-136
Unsurfaced
Oiled
Sec. A
Paso Robles
Templeton
Sec. B
Sec. B
Atascadero
Sec. C.
Santa Margarita
Oil Macadam
Poor
Sec. D

CALIFORNIA HIGHWAY STUDY

ROUTE Nº 2
SANTA BARBARA CO.

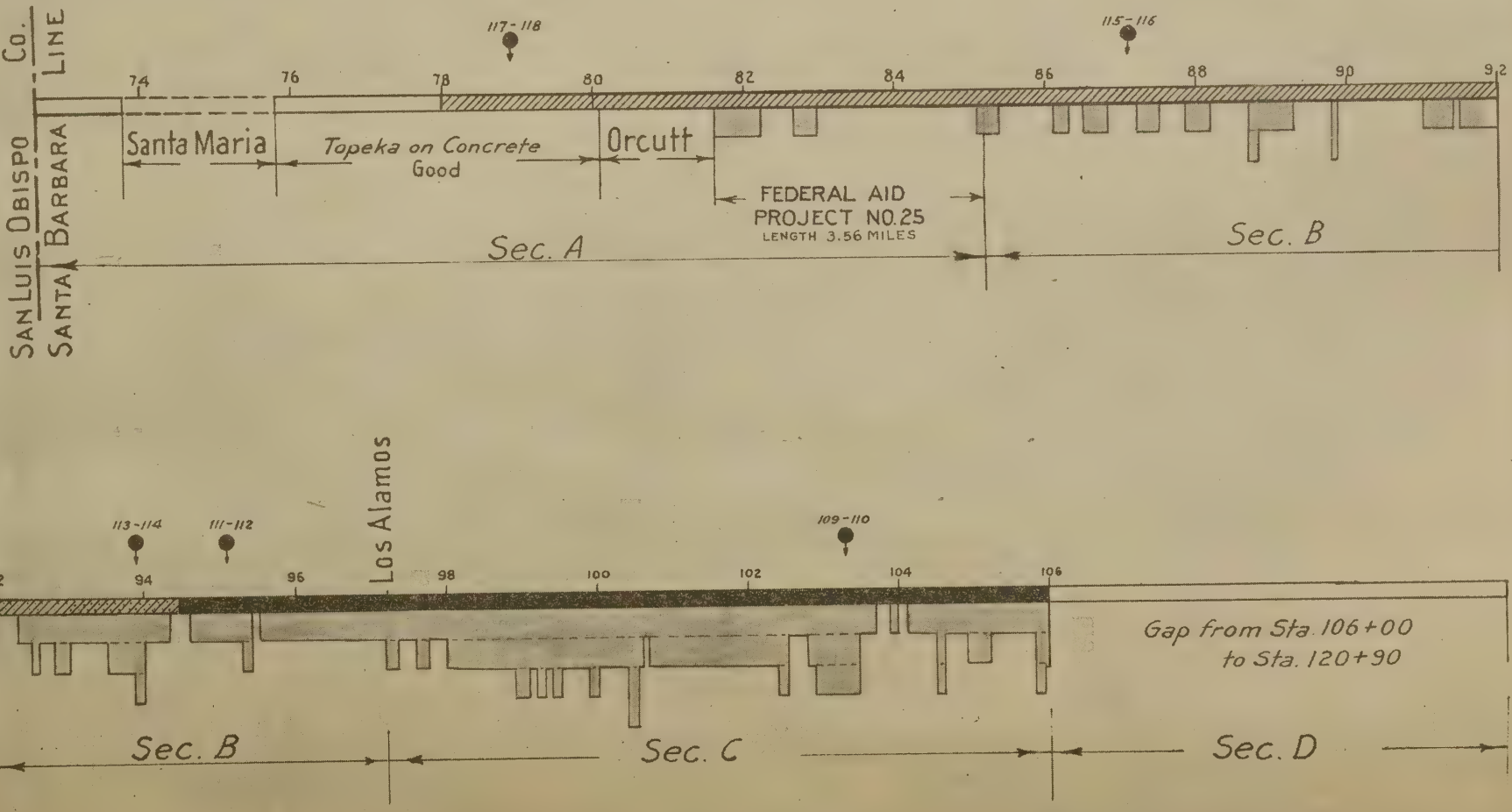
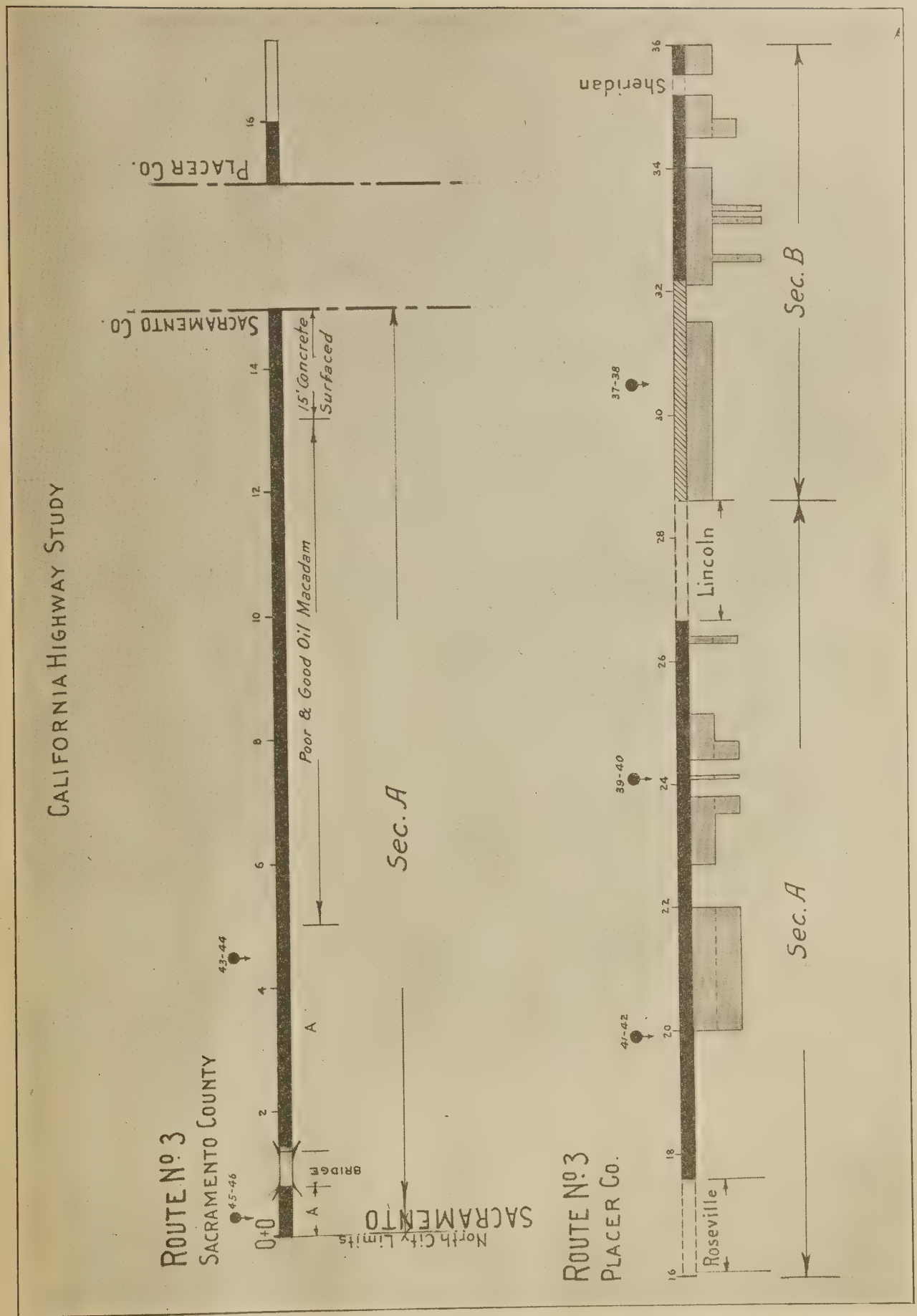
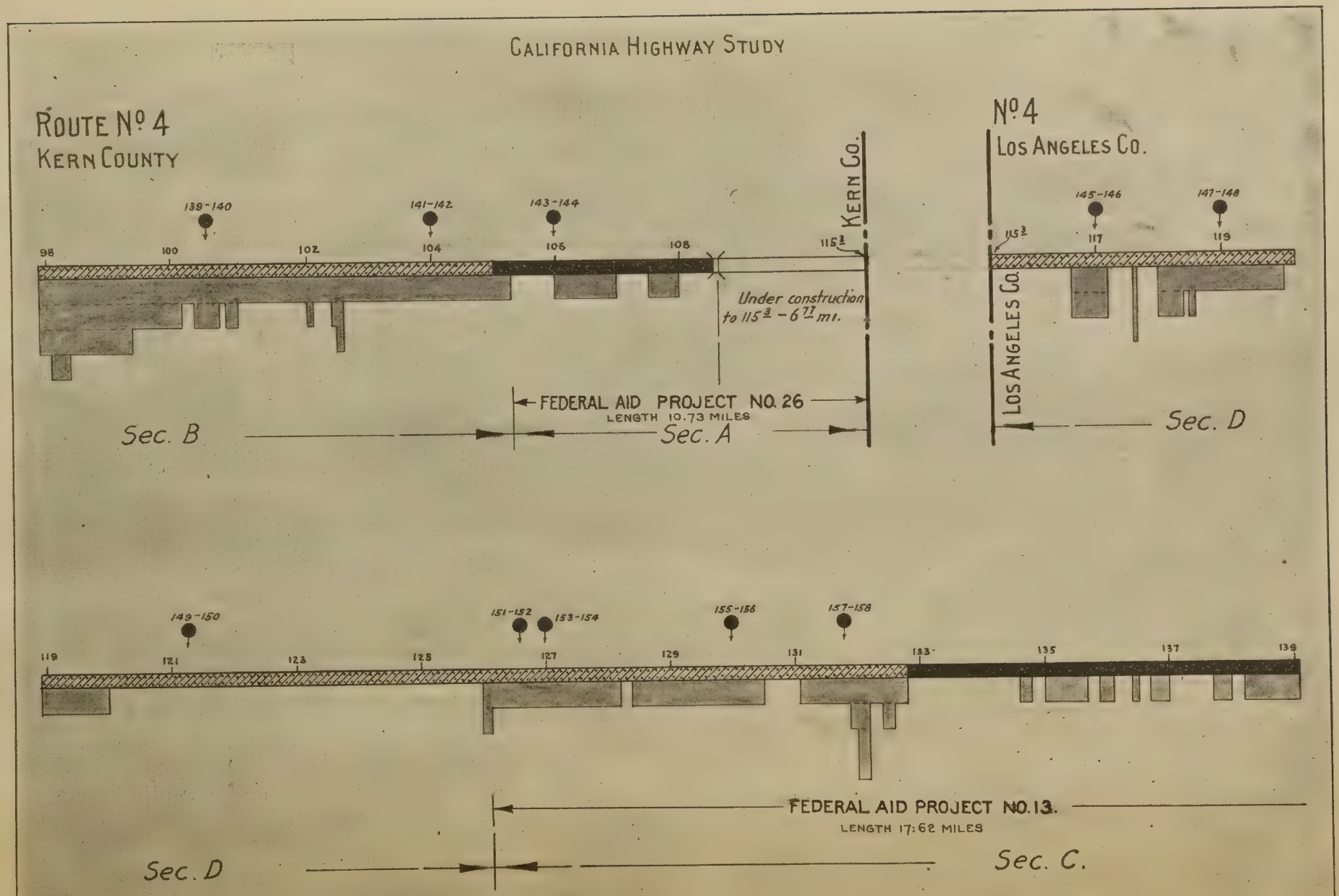


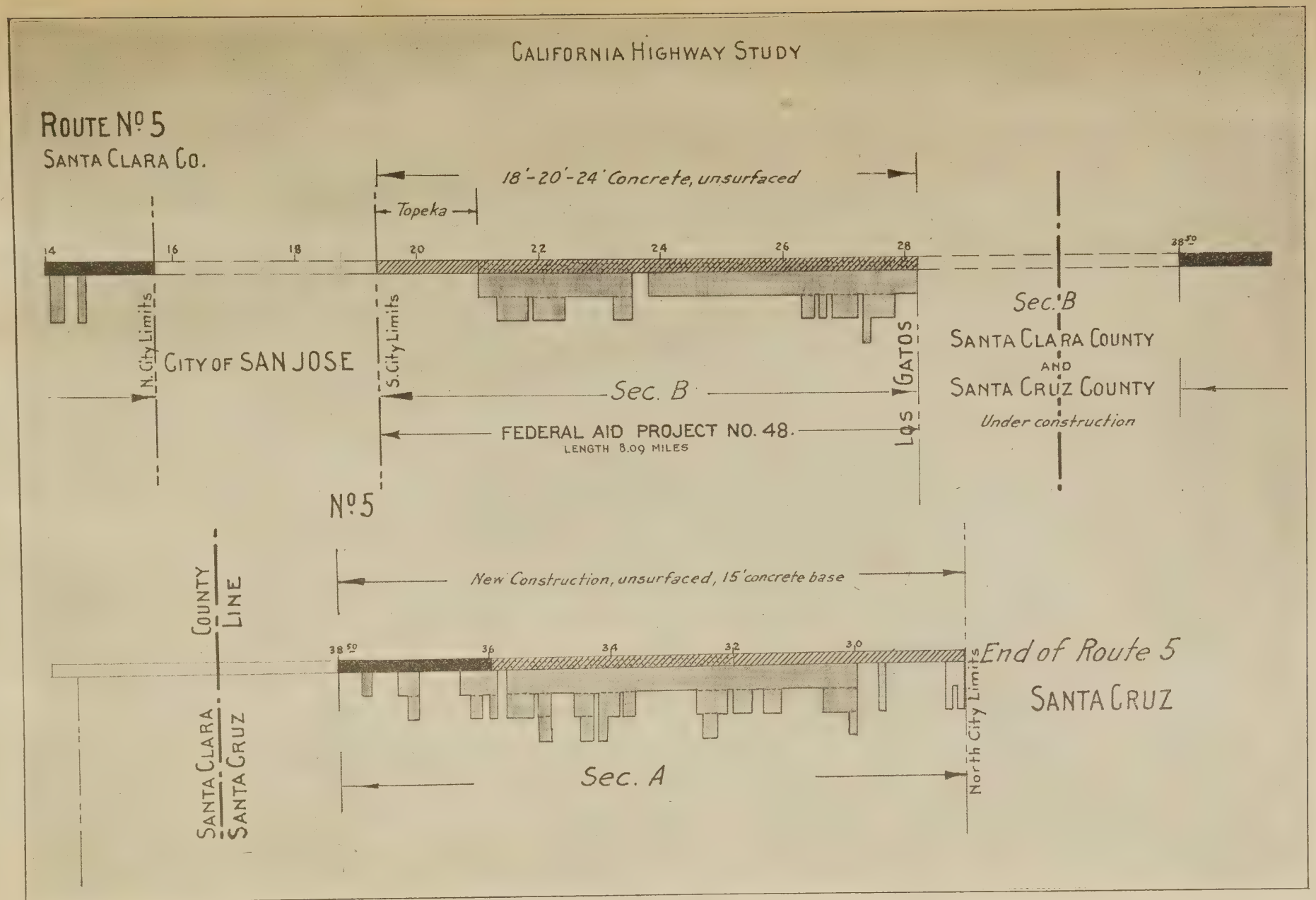
PLATE LXXV.

PLATE LXXVI.


CALIFORNIA HIGHWAY STUDY
ROUTE No. 3
SACRAMENTO COUNTY
SACRAMENTO
North City Limits
0+0
45-46
43-44
BRIDGE
15' Concrete Surfaced
Poor & Good Oil Macadam
Sec. A
SACRAMENTO Co.
PLACER Co.
ROUTE No. 3
PLACER Co.
Roseville
41-42
39-40
37-38
Lincoln
Sheridan
Sec. A
Sec. B

California Highway Study




CALIFORNIA HIGHWAY STUDY
ROUTE Nº 5
SANTA CLARA CO.
18'-20'-24' Concrete, unsurfaced
Topeka
14
16
18
20
22
24
26
28
38.50
N. City Limits
CITY OF SAN JOSE
S. City Limits
Sec. B
LOS GATOS
Sec. B
SANTA CLARA COUNTY
AND
SANTA CRUZ COUNTY
Under construction
FEDERAL AID PROJECT NO. 48.
LENGTH 8.09 MILES
Nº 5
New Construction, unsurfaced, 15' concrete base
COUNTY LINE
38.50
36
34
32
30
End of Route 5
SANTA CRUZ
SANTA CLARA
SANTA CRUZ
Sec. A
North City Limits

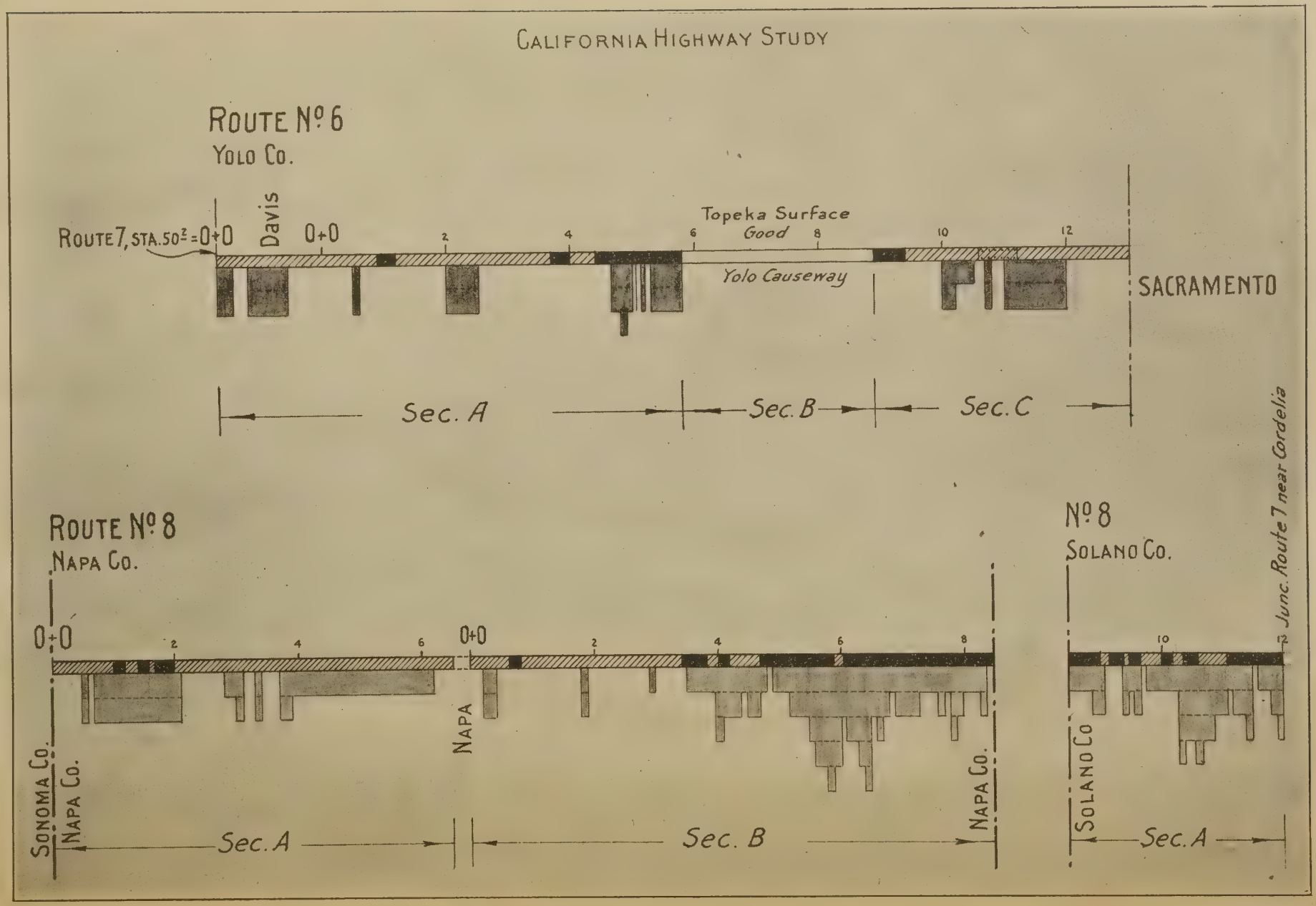
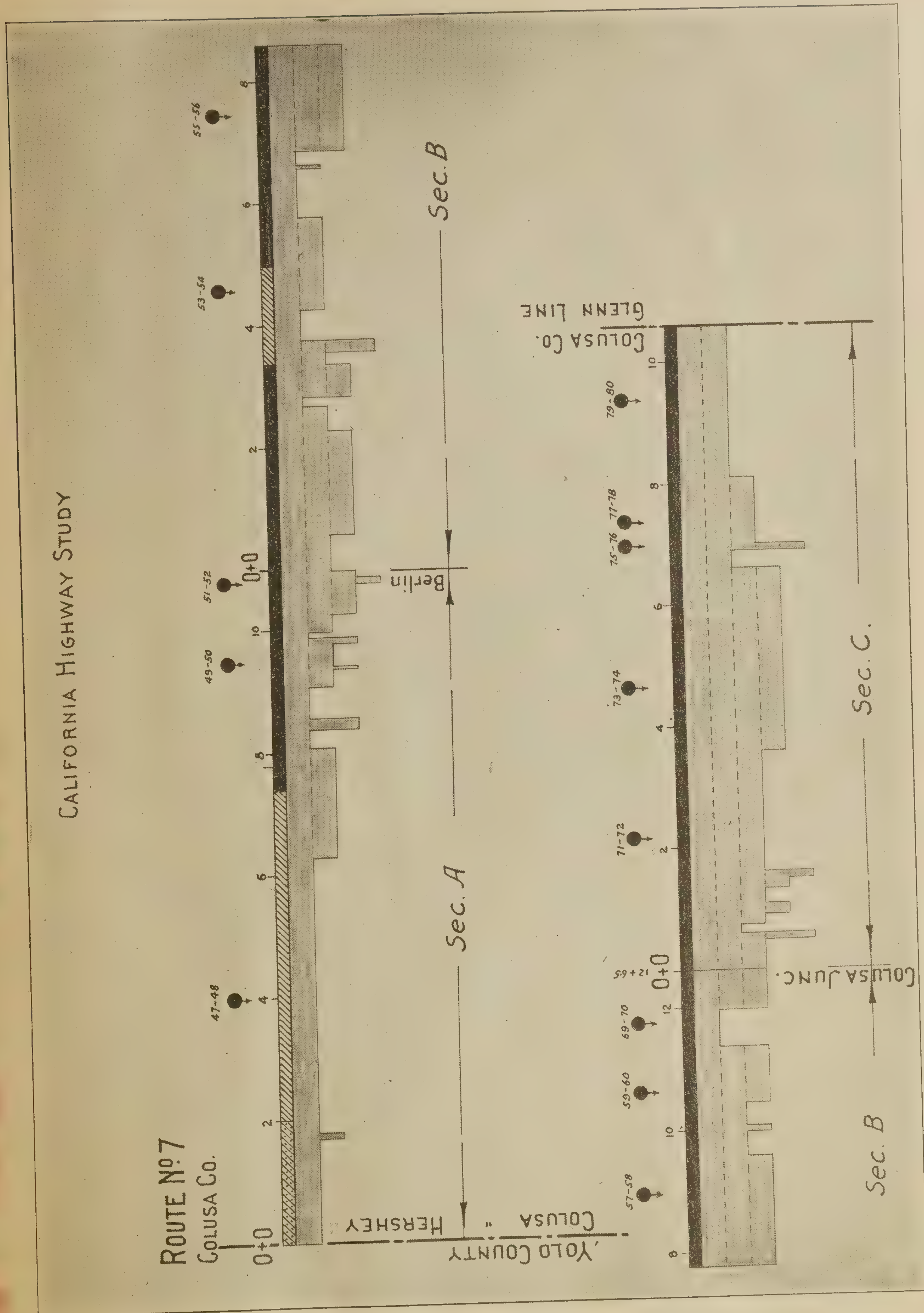

CALIFORNIA HIGHWAY STUDY
ROUTE Nº 6
YOLO CO.
ROUTE 7, STA. 50² = 0+0
Davis
0+0
2
4
6
Topeka Surface
Good
8
10
12
Yolo Causeway
SACRAMENTO
Sec. A
Sec. B
Sec. C
ROUTE Nº 8
NAPA CO.
0+0
2
4
6
0+0
2
4
6
8
SONOMA CO.
NAPA CO.
NAPA
NAPA CO.
Sec. A
Sec. B
Nº 8
SOLANO CO.
10
Junc. Route 7 near Cordelia
SOLANO CO
Sec. A

PLATE LXXIX.


California Highway Study
Route No. 7
Colusa Co.
Yolo County
Colusa
Hershey
Berlin
Sec. A
Sec. B
Colusa Junc.
Sec. C.
Colusa Co.
Glenn Line

CALIFORNIA HIGHWAY STUDY

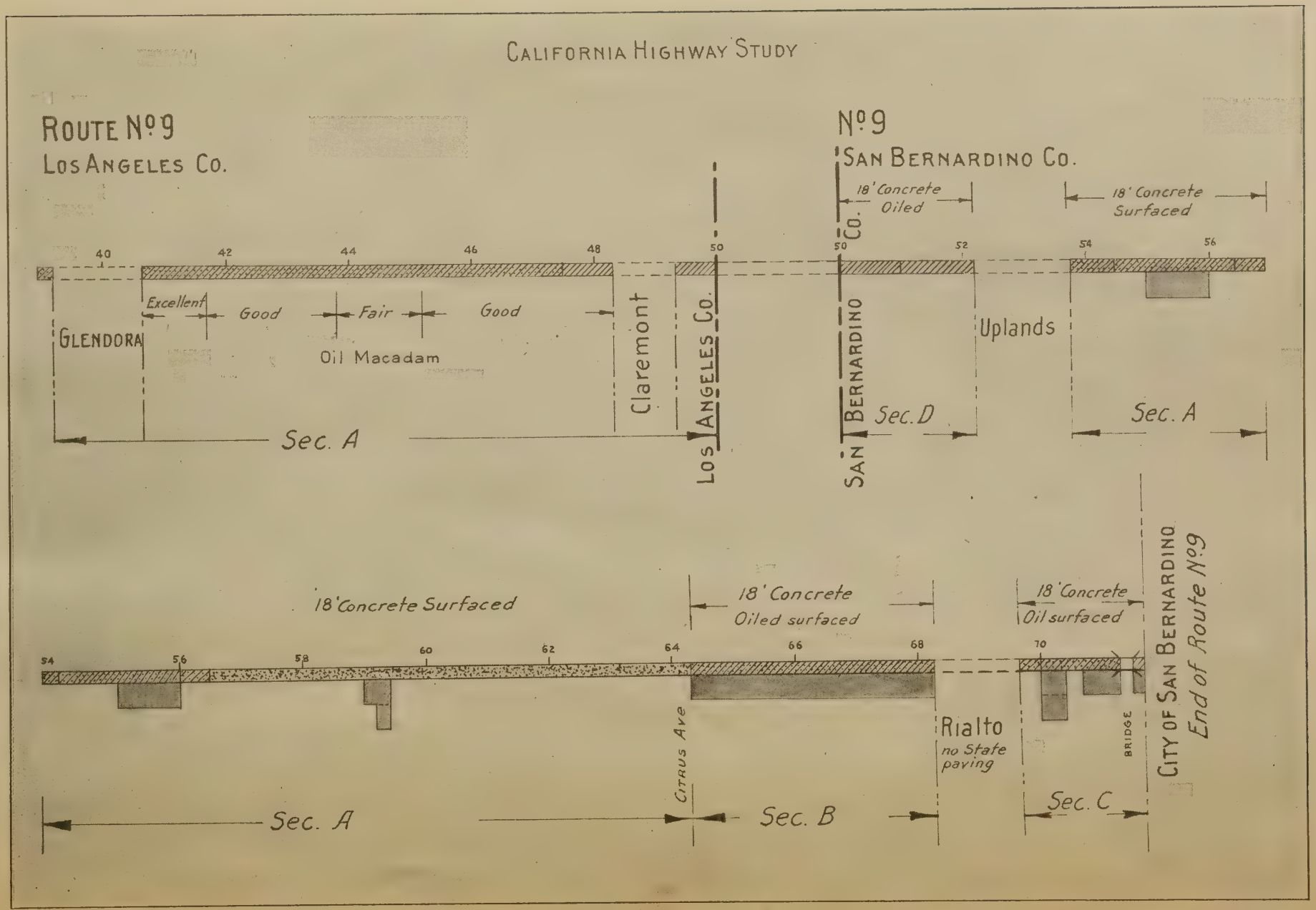
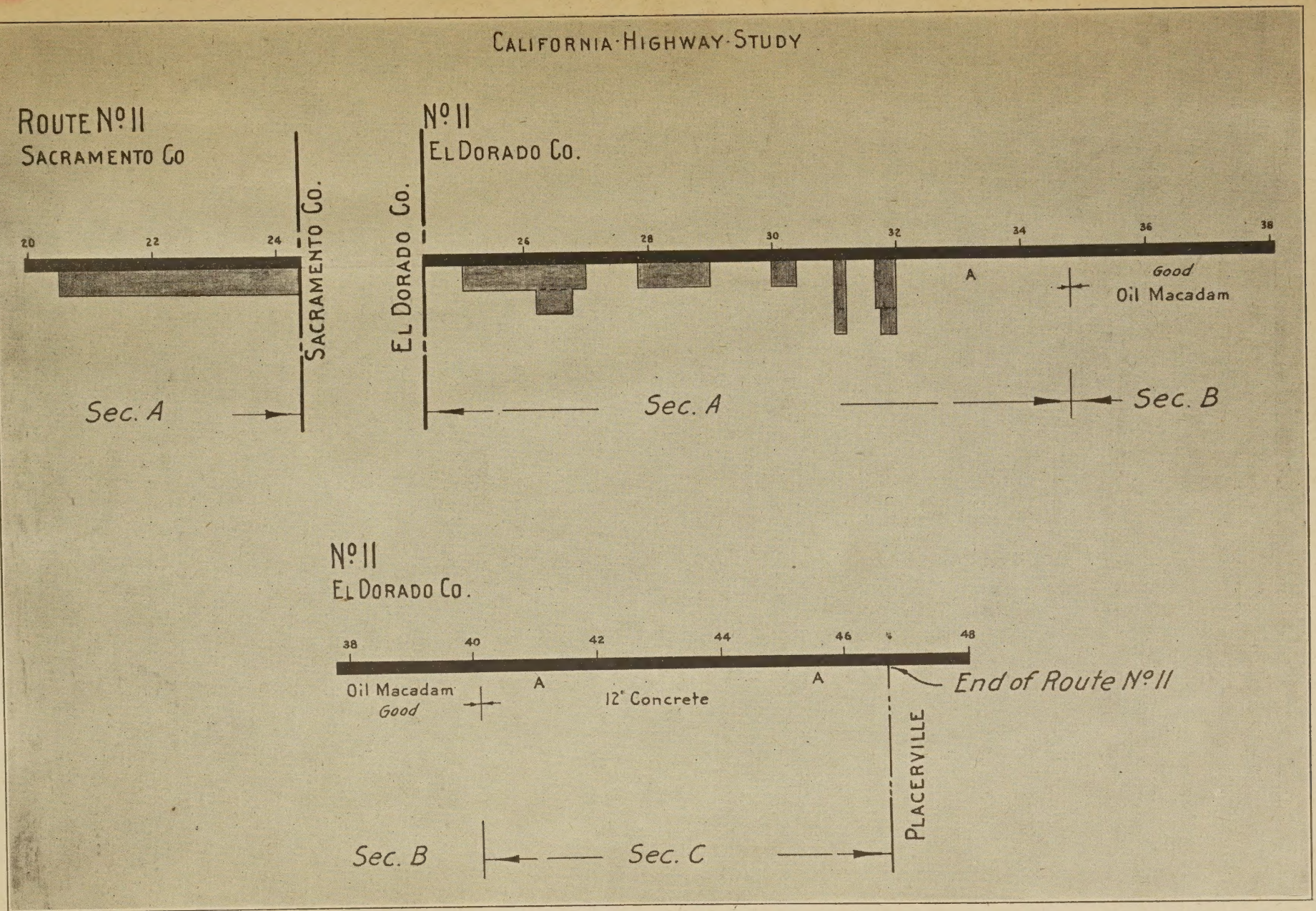
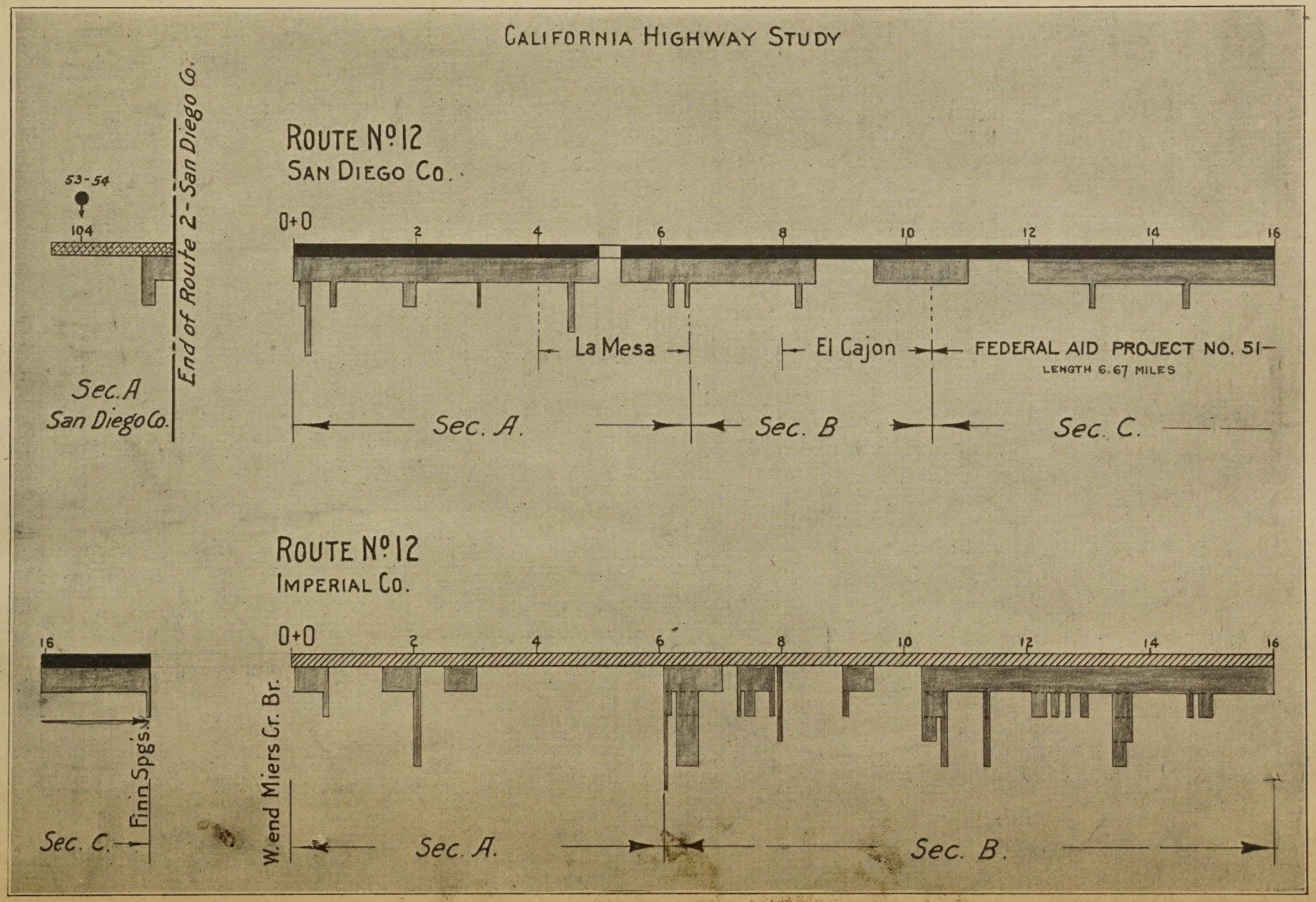


PLATE LXXXI.


CALIFORNIA·HIGHWAY·STUDY
ROUTE Nº 11
SACRAMENTO Co
20
22
24
SACRAMENTO Co.
Sec. A
Nº 11
EL DORADO Co.
EL DORADO Co.
26
28
30
32
34
36
38
A
Good
Oil Macadam
Sec. A
Sec. B
Nº 11
EL DORADO Co.
38
40
42
44
46
48
Oil Macadam
Good
A
12" Concrete
A
End of Route Nº 11
PLACERVILLE
Sec. B
Sec. C

75712—22——12


53-54
104
End of Route 2 - San Diego Co.
Sec. A
San Diego Co.
ROUTE Nº 12
SAN DIEGO CO.
0+0
2
4
6
8
10
12
14
16
La Mesa
El Cajon
FEDERAL AID PROJECT NO. 51
LENGTH 6.67 MILES
Sec. A.
Sec. B
Sec. C.
ROUTE Nº 12
IMPERIAL CO.
16
Finn Spgs.
Sec. C.
0+0
2
4
6
8
10
12
14
16
W. end Miers Cr. Br.
Sec. A.
Sec. B.

·California·Highway·Study·
Route No. 15
Colusa County
Junction of Route 7
0+0
1-2
3-10
7-8
5-6
3-4
Sta. 8+65 m.
End of Route 15
Colusa
Williams
Sec. A
Route No. 17
Placer County
Nevada Co.
Grass Valley
Auburn
Nevada City
0+0
0+0 = 65
Gap of 26 mi.
Penryn
Loomis
Roseville
Sec. A
Sec. B
Sec. B

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
30 CENTS PER COPY

▽